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McMASTER UNIVERSITY
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Design Criteria for Energy Efficient Neighbourhood Planning

city of hamilton

005284

Prepared by the Planning and Development Department of the Regional Municipality of Hamilton-Wentworth for the City of Hamilton.

September, 1982

ACKNOWLEDGEMENTS

This report represents a logical continuation of the City of Hamilton's energy related planning activities that began in 1975.

The 1978 report, "Energy Considerations in Urban and Regional Planning", prepared by the Planning and Development Department, created a strong awareness of the energy situation at the community level. In 1981, the City published a much acclaimed report entitled "Planning for Low Density Development - A Solar Approach", which established basic subdivision design parameters.

It is the purpose of this report to define the need for and develop a detailed set of appropriate energy policies and design criteria to be used in the neighbourhood planning process.

This report is indebted to the numerous external advisors whose insight and suggestions were gratefully received. The Planning and Development Department of the Regional Municipality of Hamilton-Wentworth wishes to thank the City of Hamilton for its courage and conviction to challenge convention and promote energy efficient land use planning.

A special thank you is extended to both the Ontario Ministry of Energy and the Ministry of Municipal Affairs and Housing, without whose support and cooperation this project would not have been possible.

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Part One

Formal Prologue

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The style and manner in which land has been developed for residential use in the past can hardly be justified in a time of escalating costs and a diminishing supply of non-renewable sources of energy. The challenge lies in modifying the urban form. Part of this challenge is the fomulation of urban design strategies which would ensure energy efficient development.

Accordingly, the objectives of this study are:

- i) to develop and instill an energy conscious neighbourhood planning philosophy;
- ii) to determine the most appropriate set of energy efficient design criteria for the planning of neighbourhoods;
- iii) to formulate a set of detailed policies designed to encourage energy efficiency in land use and neighbourhood planning; and
- iv) to promote energy conscious planning techniques in conjunction with all participants in the planning and development process.

Unless our concepts of homes and neighbourhoods are altered, our attempts at energy efficiency are limited to optimizing present situations. Single family detached housing is, and will continue to be, the preferred neighbourhood form, yet this type of development is the most energy inefficient. The present evolution of energy efficient land use planning must design with this paradox to achieve sub-optimal solutions.

As detailed in the Study Proposal to the Ministry of Municipal Affairs and Housing, there are three major stages in this study. This report documents Stage One.

Urban and regional planning play a fundamental role in determining the patterns of energy consumption in the built environment. The manner in which Hamilton's land resources are developed in terms of form, use, and intensity of development affects infrastructure requirements and energy costs for decades.

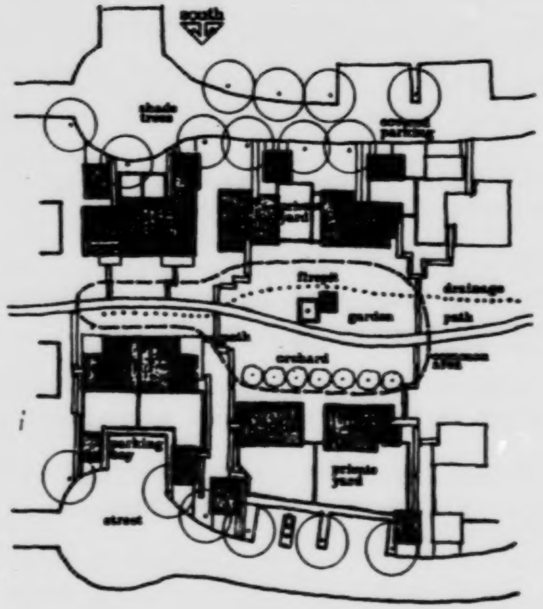
Hamilton possesses an infrastructure which requires an enormous amount of energy to function effectively. Development policies formalized in an era of cheap energy abundance continue to play key roles in all levels of urban planning. As a result, land uses are space extensive, automobile oriented, and specialized into segregated land use categories with little thought given to energy conservation.

Attitude surveys and opinion polls of recent years indicate a high degree of public awareness, yet people still consider energy conservation in terms of modest inconvenience. As a result, conservation efforts have focused on short term strategies with relatively simple implementation: reduced speed limits, lower thermostat settings, car pools, propaganda campaigns, etc. However, as the more obvious energy conservation options are exhausted, strategies requiring longer implementation and offering greater results will take priority, e.g. changing the urban form by grouping structures closer together to reduce the use of automobiles and increase thermal efficiency.

Our sources and use of energy, together with associated costs, will inevitably result in massive changes in the manner in which future land use is planned. Already, the omnipresent concept of energy has altered perspectives and is forcing municipal adminstrators to modify outdated ideals. Specifically, planning policies and building design must ensure that the amount of energy used for a given function is reduced.

Hamilton, through its Official Plan, states dedication to the promotion of energy conservation. Section C.8: *"Development which minimizes energy consumption and emphasizes the use of renewable energy sources is actively encouraged by Council."* Such policy statements are a necessary step towards energy conservation; they express municipal concerns and commitments and may even encourage others to adopt energy conservation measures, but, by themselves, blanket encouragements are not sufficient to change development patterns to accommodate energy efficiency.

This report focuses on the development of a new approach to urban planning, complete with design criteria, guidelines, and the establishment of a prescriptive and performance framework within which goals and policies promoting energy efficiency may be implemented. Hamilton's innovative leadership in research, data collection, demonstration, and energy efficient planning at this time will be rewarded when energy conservation programs become politically demanded.


south
shade trees
parking
drainage
garden
path
orchard
common area
parking
private yard
street

The now famous Village Homes subdivision in Davis, California, incorporates many physical and social design features to conserve energy.

BARRIERS TO ENERGY EFFICIENT LAND USE PLANNING

General resistance to energy efficient planning and the barriers to implementation can be attributed to the following constraints:

1. *conservation is too often erroneously interpreted as sacrifice;*
2. *energy efficient design principles, such as mixed land use, are perceived as lower standards of living and unacceptable social costs;*
3. *the actual dollar savings of energy efficient planning versus conventional planning are unknown;*
4. *it is not realized that buildings which are not energy efficient will depreciate faster than buildings which are;*
5. *developers have no incentive to take the risks necessary to test consumer acceptance of innovative alternatives, and municipalities and consumers do not appreciate the wide benefits of energy efficiency, e.g. life cycle costing;*
6. *innovation is impeded as decision-making among the key actors of the industry (developers, financial institutions, designers, municipalities, utilities, construction trades) is decentralized and fragmented;*
7. *guidelines and tools through which to implement and evaluate energy efficient development are either non-existent or exist but are not used; and*
8. *energy efficient design faces disincentives and discouragement from bureaucracy where there is an unwillingness to tamper with convention, especially when long term benefits are not necessarily politically acceptable in the short term.*

The above barriers are largely attitudinal in nature. There are no design or technological barriers to building energy efficient neighbourhoods. All levels of government, together with the development industry, must create a marketing strategy that will entice consumers to accept energy efficient developments as the preferred norm. Just as large gas guzzling cars will soon become a memory, ingrained personal and social values based on cheap energy will adapt to accept energy efficiency in urban design.

Fluctuating energy prices and the absence of a concise energy policy at the national level has understandably left many municipal administrators and planners somewhat confused as to the present, and particularly future, energy situation. Still, municipal governments are often criticized as being responsive to local demands but unable to provide the direction necessary to deal with emerging problems. As a result, neighbourhood planning, as it is generally practised today, merely avoids conflicts between various land uses and protects vested interests by stamping the future from a past cast. In this type of situation, municipalities can do little but respond to demands rather than provide effective leadership in energy conservation.

An enlightened concern for energy efficiency offers the potential to refine existing neighbourhood planning concepts and mitigate the impacts of increasing energy costs. From the City's economic viewpoint alone, the exponentially increasing cost of energy will have a significant effect on the municipality's ability to provide equitable services without increasing the tax levy or decreasing the level of service.

To this end, numerous reference sources prescribe the centralization of infrastructure, land use, and activities to conserve energy in the future. They often depict a future where there is [illegible] urban sprawl, no strip development, and strict land use control. Mixed land uses are clustered along transit corridors. Multi-unit low rise dwellings dominate [illegible] integrated neighbourhoods. High rise apartments are almost extinct; many structures are buried in the ground; with district heating, recycling centres, and urban farming commonplace. Yet rarely do these documents describe the behavioural changes necessary for the implementation of prerequisites such as increased densities or reduced automobile use.

We must heat our homes and cars are but a cultural necessity, irrespective of the price of oil. Thermostats can be lowered, insulation levels improved, and we can drive less, but thereafter the individual cannot do much more. Whatever "securities" the national energy policy may achieve remain to be seen, but higher costs for consumers are a certainty. For the less affluent, who are already spending up to a quarter of their income on energy, every day a decision is made between food versus heat and transportation.

Energy conservation within rental developments are also a municipal concern because the tenants of such developments usually lack the legal authority to make the changes necessary to conserve energy. Individuals who own a residential unit can perform the changes required to improve its energy efficiency, whereas renters or tenants have very few options in this area and will continue to pay increasing utility and heating bills. Even individuals who own their own residences usually have very little influence in the siting and design of their residence. Only individuals financially capable of having their residence custom built can dictate that the building be constructed in an energy efficient manner.

Few of us are concerned with saving energy for any other reason than gain. Simple common sense measures like turning off lights when not in use required huge price increase to overcome cultural inertia. Therefore, the onus is on the municipality to encourage and require the incorporation of energy conserving design in new development.

As the cost of energy increases at a faster rate than income levels, governments will be pressured towards increased subsidization at the wrong end of the problem. Rather than continue backward solutions, it is easier and less costly to incorporate energy efficiency into a building or development site during the initial construction stages than retrofitting or subsidizing an individual's energy payments.

It is an economic certainty that conventional homes will depreciate faster than homes which are energy efficient. New neighbourhood developments possess a relatively large percentage of homeowners who inherently possess dollar value concerns. These concerns are often vented upon munipalities which fail to protect the vested interests of homeowners.

The complexity of energy conscious planning is generally recognized. Even if it is narrowed down to the neighbourhood scale, energy conscious planning still is obscure and it appears that there are a number of ways of approaching it. Nobody is certain which way is the best one.

A municipal planner, administrator, or elected representative who recognizes the need for an intelligent response to the emerging imperatives is further frustrated by two sometimes mutually supportive, but usually exclusive, schools of thought.

One is the "muddling through" approach. In this case, we are supposed to solve our problems as we go, and we should not be overconcerned with long term responsibilities. If there should be any serious problems in the future, we will solve them when we get there. The values and expectations which were acquired during energy devouring times are sacrosanct. Thus, the stress is on quick, visible actions or fixes of a minor nature which could bring immediate, real or imagined, relief to the present burden.

The other approach advocates the need for a deeper understanding of our present turmoil, a need for planning our settlements in the context of broader technological and societal changes. The stress is on a long range perspective and on actions which would make that distant goal possible. The major argument in favour of this philosophy is that short term and short-sighted actions might in fact run contrary to our long term interests. By using the wrong medicine for a minor injury, we may contract a serious infection. Thus, short lasting relief could be exchanged for a time bomb which might explode in a couple of decades. Our grandchildren would curse our memories.

Having these, in addition to energy related problems in mind, the report was divided into a number of parts.

The neighbourhood designer who wishes to improve conventional layouts in a non-revolutionary way could flip through the pages of the "Designer's Notebook" and related pages in the "Appendices". Slightly more daring ideas are included under the heading "Human Factors, et cetera" at the end of PART TWO. A neighbourhood planner who is genuinely interested in an alternative approach to neighbourhood design and planning has to suffer through all of PART TWO of this report.

A planner involved in policy formulation, coordination, and Official Plan preparation would eagerly read PART FOUR ("Policies and Guidelines") and PART FIVE ("Land Use Controls"). Ideas and suggestions expressed in this part of the report are almost ready-made to be incorporated into municipal documents. The policies and recommendations included in both PARTS FOUR and FIVE are based on a thorough research of what other municipalities are doing, what appears to work for them and what could, hopefully, work for us.

However, policy planners who are also interested in understanding principles and different approaches must not ignore PART TWO.

In summary, this report was written for different types of professionals and non-professionals with different depths of interest.

As a footnote, we wish to stress that PART TWO, "The Energy Efficient Neighbourhood - An Emerging Challenge", is an attempt to introduce an alternative approach to neighbourhood planning. Only further discussion and scrutiny during the second and third stages of this research project, and perhaps even discussion and scrutiny taking place outside of our municipality, will determine the acceptability and merit of the proposed ecological approach.

Part Two

The Energy Efficient Neighbourhood – An Emerging Challenge

ELUSIVE ANSWERS

Energy efficiency can be achieved by a variety of ways. While some methods are complementary, others exclude each other. In reviewing the existing literature on the subject, it becomes obvious that our energy lobby is divided into a number of groups advocating a number of solutions. In some cases, the solutions resound with a self-righteousness and messianic duty which is reminiscent of the passion of religious fanatics.

Obviously the consequent confusion may significantly slow our energy conservation and management efforts. To avoid fruitless sectarian battles, it is time to initiate some attempts at synthesis. This is particularly important for an urban planner. He is supposed to advise the decision makers (the true planners) which way to throw tons of bricks, wood, concrete and steel. Once in place, they are difficult to move. Many generations might bear the consequences of a few lines of an urban planner's report. Thus clarity in the actual as well as the professional planner's mind is of paramount importance.

The following should be viewed as an honest attempt to contribute to a wholistic picture of the problem. It is far from being complete and is based on a review of research work done by others. The selection of facts, hypotheses and ideas was based on the writer's general professional experience and intuition rather than on any direct involvement in original research and experiments.

We are told that energy conservation is a great source of energy. It has to be understood, however, that those magnificent amounts of saved energy are available due to our disregard of energy efficiency in the past. Undoubtedly, when energy efficiency becomes a norm, there will be less room for energy conservation. After that, the only conservation which can take place is at the price of personal comfort (sweating in the summer, shivering in the winter) but this is an emergency measure rather than a blueprint for a normal, happy course of life.

What then?

Obviously, our efforts must be directed towards efficiency and towards management. Unfortunately, experts cannot agree on which way to go. The recent termination of the cheap oil era left us in a state of shock. The tremor is far from being over. The environmental consequences of the utilization of other buried energy batteries such as uranium or coal make many minds confused and uncertain.

This is certainly a contributing factor to our current intellectual snobbery of turning our backs on high technology. Although it would be naive to completely eliminate high technology from the human agenda, the present sentiment does have a definite and positive effect. It provides us with the opportunity to research alternatives and to view and understand the world from a different perspective than that which prevailed during the days when we were drugged by a confidence in technological fixes.

Ultimately, this period of doubts and questions should be of benefit to researchers and scientisits involved in high technology systems.

TERRESTRIAL ENVIRONMENT

Our search for alternative solutions must begin by observing and better understanding our terrestrial environment. The apparent complexity which we are surrounded with is a product of the integration of three basic natural phenomena:

- gravity (the "constant" force);
- topography (the "constant" base);
- the spinning of the earth round the sun (the "cyclical" exposure to the sun's radiation).

As a result, every passenger on this spaceship earth can observe:
- the diurnal/nocturnal cycle, and
- the seasonal or annual cycle.

Every natural, living, non-living, or man-made system which is located on the surface of the earth is subject to these terrestrial and extraterrestrial environmental forces.

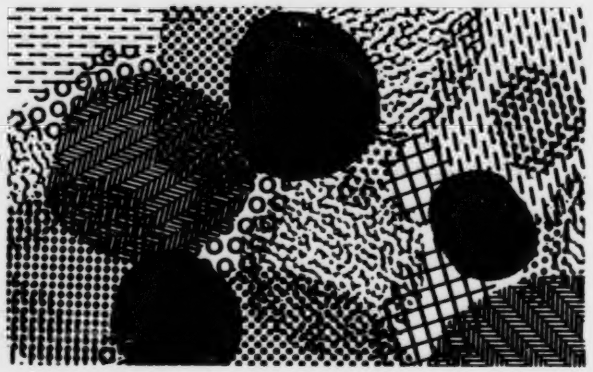


FIG. 1

A graphic representation of the total reality is next to impossible. We are observing the overlay of a three dimensional and dynamic situation. We are dealing with a never ceasing array of conflicts. The elements are continously setting a balance which is continuously being disturbed.

According to one convenient classification method, the world we see and are a part of consists of three types of systems:

1. Open Systems - exhange information, matter, and energy with their surroundings;

2. Closed Systems - exchange only energy with their surroundings;

3. Isolated Systems - exchange nothing with their surroundings.

All living systems and man-made eco-systems (such as shelters, buildings, communities) are open systems. Their survival depends on the successful exchange of information, matter and energy.

INDIVIDUAL SYSTEMS

A somewhat simplified picture of an open system would show the presence of a skin, which is usually breathable and equipped with sensors to monitor the outside environment (information input), and it would possess gates for trading energy and matter. The inner environment, protected by the skin, is where metabolism,

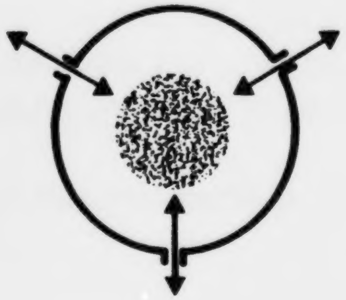


FIG. 2

based on a continuous flow of energy and matter, takes place.

The susceptibility of this system to environmental variation stresses is determined by a number of factors:

- The surface to volume ratio (depending on the form, the same surface area can host different volumes - page 105);

- The physical properties of the skin:
    - filtering, reflecting and absorbing capacity,
    - general strength,
    - elasticity (limits, tolerances),
    - fatigue, life expectancy,
    - cost of upgrading and maintenance;

- The level of metabolism (the rate of devouring energy).

EXTERNAL FORCES

The outside environment is an inexhaustible source of life supporting as well as life destructive forces. The impact of environmental stress on an individual living system can be described as follows:

- Deformation is confined within the limits of elasticity. A system is able to restore its original state. No harm is done.

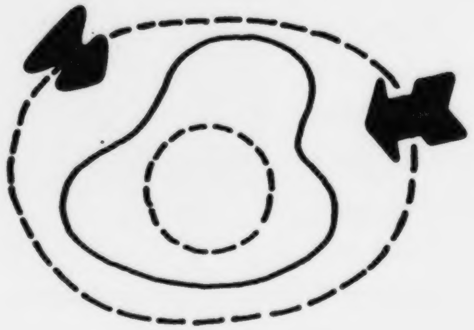


FIG. 3

- Deformation is not confined within the limits of elasticity. Environmental forces which extend over the extreme limits of the

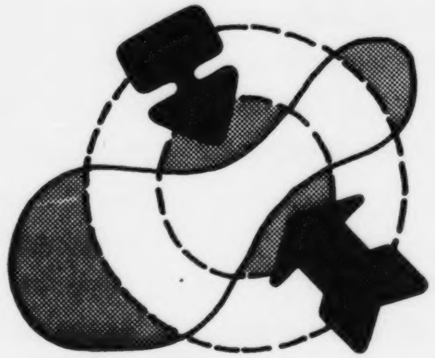


FIG. 4

system's elasticity cause a permanent deflection (scars). The system is unable to resist or cope with the stress and restore its lost balance. Environmental forces become destructive.

Defensive and Remedial Options:

(a) Before attack (environmental catastrophe):

- anticipation	by a continuous monitoring of the outside environment; information and data gathering and processing;
- prevention	by form adjustment and modification, envelope reinforcement (fortification), energy storage, a boosting of the metabolism and inner resistance;
- avoidance	by a change in location (if system is mobile).

(b) After attack (environmental catastrophe):

Once a permanent deformation has taken place, a limited number of healing, repairing, corrective, restoring and upgrading actions are available.

It should be obvious that those measures which are taken before attack/catastrophe are less expensive and less complex than those which are applied after the attack/catastrophe.

SURVIVAL STRATEGIES IN A DYNAMIC ENVIRONMENT

All living systems are programmed to pursue their own survival. This is achieved by harnessing energy and matter from the environment and by resisting/avoiding anything destructive. The key element of success is a continuous monitoring of the environment (gathering and processing information).

In essence, the art of survival lies in maintaining internal equilibrium - an oasis of stability in an unstable world. Thus, since internal equilibrium implies stability, stability implies predictability. Predictability implies survival of the system over time.

The logic circuit is completed and the programming (for survival) is done.

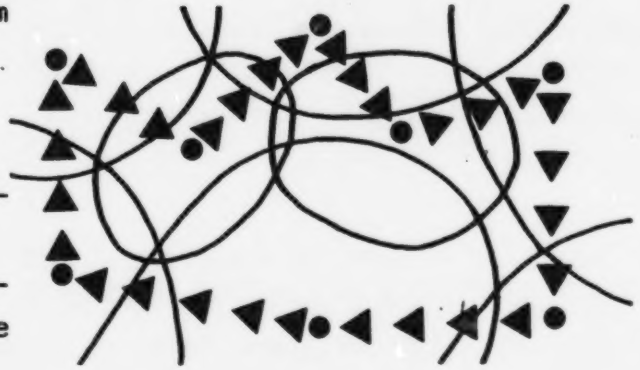


FIG. 5

Escape is a form of response to hostile (destructive) environmental forces and to anticipated catastrophes. Mobile living systems have a unique ability to avoid catastrophic situations by running away. In other words, in order to secure the exchange of material, energy and information necessary for their survival, some mobile living systems are continuously seeking more advantageous (suitable) areas.

Systems with either limited or no moblity can secure constancy of their internal environment by the following strategies:

1. Shape Adaptation and Adjustment

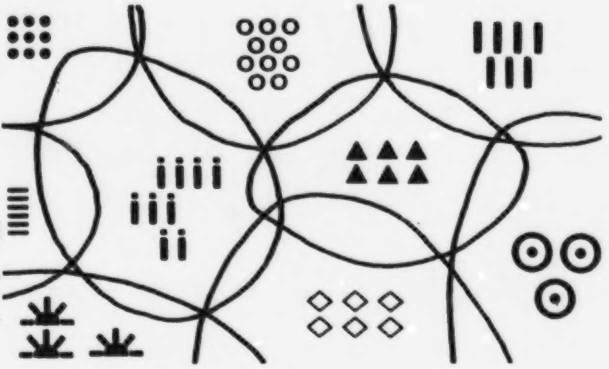


FIG. 6

Environmental conditions differ from area to area. Thus, we can observe a variety of living system shapes reflecting the particular conditions of a given environmental area or a region. Furthermore, environmental conditions are never constant. They are subject to diurnal and annual changes. As a result, certain species not only develop/adapt their shapes according to the specific local conditions but their shape also follows the rhythm of seasonal variations.

2. Energy and Matter Devouring

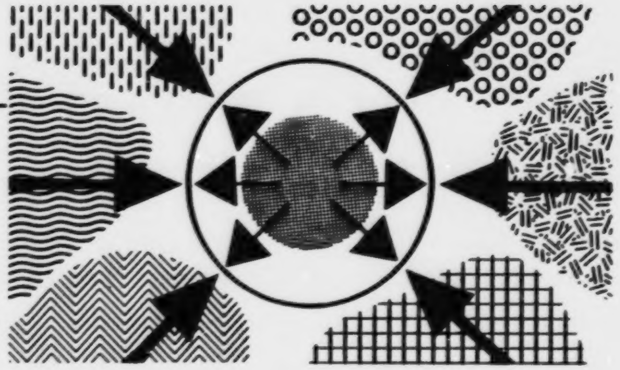


FIG. 7

In some cases, when a powerful and easily accessible source of energy is available, there is an alternative to "running" and to shape "adaptation/adjustment". Both the local environmental peculiarities and the rhythmic beat of diurnal and annual variations can be offset by an increased input of energy and matter. Such a frantic devouring and processing of energy and matter results in a wonderful possibility: systems can locate themselves irrespective of natural stress areas and can ignore the repetitive pounding of seasons.

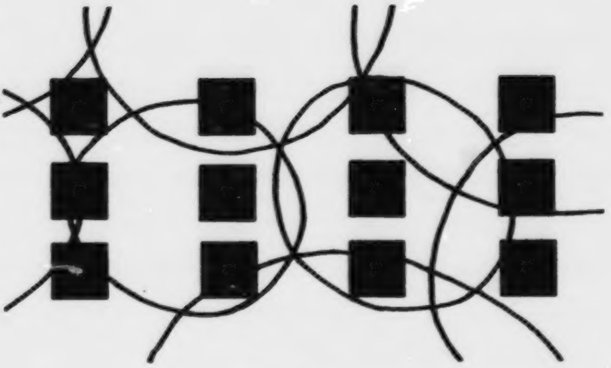


FIG. 8

Needless to say, this sort of environmental independency has a tremendous appeal. Our human perception associates this exciting concept with power and ultimate freedom. On the other hand, from time to time history reminds us that closed or environmentally independent systems are extremely vulnerable. Any flow variation or interruption in the supply of energy can be fatal.

HUMAN RESPONSE TO SEASONAL VARIATIONS

Most anthropologists are convinced that humans evolved in a warm climate. When they (humans) decided, or perhaps were forced, to leave their "thermal paradise", they had to cope with many new challenges. Since fur as an evolutionary alternative was rejected in lieu of an enlarged brain, humans had to secure a constancy in the internal environment by a unique human way. Obviously, the first immediate response to seasonal change, one already verified and practised by animals, involved the avoidance of unpleasant times and places. As seasonal change took place, humans moved, seeking warmer, more hospitable or at least more bearable areas.

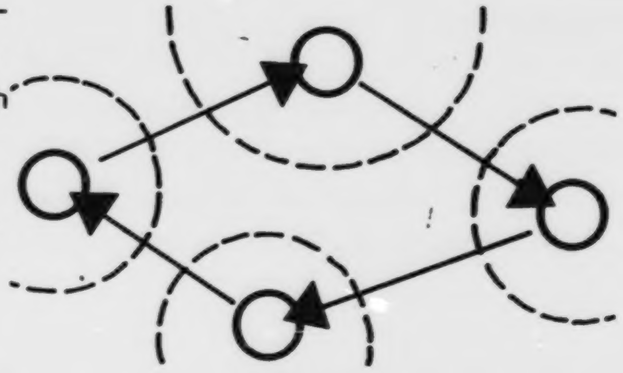


FIG. 9

The only environmental variation left to cope with was the diurnal one. But that was a relatively easy task to solve. Thermal comfort during the night was secured by erecting simple structures, or simply by taking advantage of accidental natural shelters such as caves, larger trees, etc. Usually this nomadic movement or seasonal migration established itself into a definite pattern (following the edible animals' paths) which was then repeated every year.

Local environmental conditions and seasonal changes are a product of the interaction between gravity, topography, and sun exposure. Following the path of "good times and good places", humans were taking advantage of the land as a natural solar collector. The art of survival lay in the successful collecting and processing of living solar batteries (blueberries, rabbits, . . .).

This mode of life is often glorified in literature and it can indeed offer some happy moments. In reality, it is rather hard on the feet. Statistical averages show that one square mile can support only one person and, in northern latitudes, even less. The vulnerability to weather elements was still very high. In spite of the exhausting everyday struggle, survival was still a gift. The future was unpredictable.

FIG. 10

Gradually, over a long period of time, new methods and strategies evolved. A small area became more intensely utilized. This limited territory was modified and transferred into a man-made, more efficient solar collector. Now, one square mile of land could support one hundred people. Relocation as a response to the reoccurence of seasons was replaced by the sequence of human activities.

However, with the introduction of agriculture, a new set of problems arose. With humans anchored to one place, there were obvious and very strong pressures to construct an efficient machine for equalizing environmental variations. This machine would duplicate the thermal conditions of human biological evolution. Furthermore, such a machine would maintain the constancy of its internal environment, regardless of the mess outside.

THE EVOLUTION OF HUMAN SHELTER

Nomadic shelters, designed and constructed to cope only with diurnal variations or with a short period of adverse weather conditions, were usually relatively simple machines. They were put together from a variety of elements, bits and pieces which were found right on the spot and in some cases combined with standard parts carried along with them such as fur blankets, ropes, etc. Interestingly, these early shelters, despite their simplicity, performed remarkably well.

However, it was the shelter constructed to offset seasonal variation, which was capable of imitating almost perfectly the set of environmental conditions which constituted man's biological make-up. It was a machine which had the ability to maintain a constancy in its internal environment. A duplication of and a stability in one's "thermal paradise" is a prerequisite for survival in hostile environments. With the construction of a permanent "all seasons" shelter, we began to shake off the chains of environmental dependency.

The establishment of a permanent home base is of the utmost importance for the colonization and exploitation of less hospitable or hostile environment. Thus, humankind has a vested interest in the construction of shelters. The art of construction is refined by generations and its recipes are embedded in the collective memory.

Human shelter could be viewed as an intermediary between the occupant and the natural environment. It is also a system on its own.

SHELTER AS AN AUTONOMOUS SYSTEM

Shelter is a man-made system. It surrounds its creator. As such, it could be described as an extension of a human. Its similarities with an individual living system are remarkable.

We can observe that it has a skin - a protective envelope: roof, walls, . . . - which is equipped with sensors and gates - door, windows, . . . - to facilitate the exchange of information, energy and matter with its surroundings.

The internal equilibrium (a replica of the legendary thermal paradise) is vitally important not only to the human occupant but for the "survival" of the shelter itself. Because the system is stationary, the internal equilibrium is maintained by two possible strategies:

- via energy input (plugged into a powerful energy source);
- via the function of its physical properties (adjusting the shape and construction to local environmental conditions).

A shelter system is similar to a living system in that it is susceptible to the stresses of seasonal and diurnal variations. The study and evaluation of this susceptibility could be conveniently broken down into the following elements:

- the surface to volume ratio (the same surface area can host different volumes - page 105);

- the general form/shape (page 106);

- the type of material and construction;

- the physical properties of the shell (the exterior, the exposed surfaces):
    - general strength;
    - reflecting, absorbing and filtering capacity;
    - elasticity (limits, tolerances . . .);
    - fatigue, decay, life expectancy;
    - the cost of upgrading and maintenance;

- the level of internal activity;

- the amount of energy pumped in.

Maintaining thermal equilibrium is of paramount importance to the shelter, its occupant and the whole community. Thus, it should not be surprising that the particular method of securing a bubble of proverbial thermal paradise also has profound cultural side effects.

ENERGY DEVOURING

The first method, involving energy input, is simple and comprehensive. It is particularly popular in times when an abundant, easily accessible, and high density source of energy is available. Its special charm lies in the opportunity it offers to disregard location and to disregard shape. On the other hand, this path is conducive to the justification of conquest, domination and often environmental rape.

During the last quarter of the century, we began to move towards this sort of "environmental independence". We have done this with historically unmatched speed. Bulldozers made all sites equivalent and oversized heating and cooling systems made every house a blob of paradise.

As a consequence of this newly acquired "freedom", we were permitted to enjoy unprecedented delights: the shape and construction of houses was no longer derived from the behavioural peculiarities of the local environment but rather inspired by the work of Walt Disney's cartoon studio.

This trend promptly became a part of the cultural mainstream. With the help of our accounting system and tax policies, a human dwelling became a standardized, easily traded piece of merchandise. Subsequent buying and selling of houses became a convenient and relatively quick method of creating personal assets, building up one's social status and one's real or (usually) false self-image.

In the world of frenzied house trading, the only respected value became the resale value. As individual dwellings became plugged into a powerful energy feeding system, they were able to respond to environmental variations with push button speed. The relationship between a house and the natural surroundings ceased to be a problem.

The architect and the planner dissolved their marriage and pursued their own special, independent interests. The art of building human settlements swiftly degenerated into a set of printed "how to play chess" rules which anyone could follow fairly easily.

Ultimately, there was no need for a professional at all: the architect became a draftsman and the planner a bureaucrat. Suburbs throughout the North American continent were rapidly cloned by teams of bureaucrats, laymen and paraprofessionals.

TOWARDS ENVIRONMENTAL DEPENDENCE

Inevitably, the energy conservation programs will cease to discover shockingly large reservoirs of hidden energy. Conservation then will become a cultural watchdog to prevent us from frivolous wastage. This will certainly lessen the severity of our problem, but the solution is yet to be found.

Recently we have discovered that the pursuit of environmental independence, the joyful devouring of energy, is not the best course to follow. In essence, there are two good reasons for this:

- The high energy input mode of reponse to seasonal and diurnal variation is based on seemingly abundant, accessible and inexpensive high density energy sources.

This "hook-up" makes the system - human shelter - most vulnerable to changes in the supply system, such as the availability and cost of oil, power failure, etc.

- A response to environmental cyclical forces which is based on the performance of complex mechanical systems has its limits, such as peak loading, maintenance, susceptibility to human error and ill will.

As a result, the cost of the energy necessary to maintain thermal equilibrium is prohibitively high. This painful realization leads us to a re-evaluation of the other possible strategy: shape adaptation and adjustment. Within the framework of this strategy, the architect's task would be to develop a building form which could provide adaptive responses to natural forces solely by virtue of its construction and shape. The urban planner's task would be to develop a spatial framework within which located buildings could maintain their inner equilibrium at the lowest possible cost. Also, such a spatial framework would automatically provide a predictable relationship between buildings and their natural or man-made surroundings.

ENVIRONMENTAL DOMAINS

Before we attempt to pursue a noble, powerless glide without any convenient jumbo-jets attached, we have to develop a better understanding of the environment in which we are submerged. Forgotten and long neglected skills have to be revived again.

As already mentioned, the terrestrial environment is composed of unaccountable areas - domains which have their own particular characteristics. Furthermore, we have established that we are dealing with a three dimensional and dynamic reality, with variations both in time and space. One of the prerequisites of securing a steady thermal state within the storm of elements is to map and describe the characteristics of the natural domains as closely as possible.

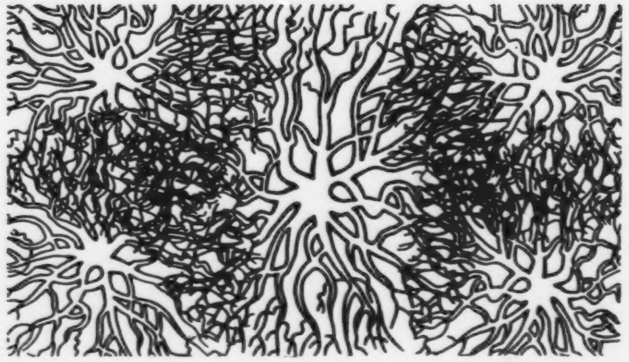


FIG. 11

In a simplified presentation, every domain has its own borders which occassionally overlap with those of other domains and continuously change with time.

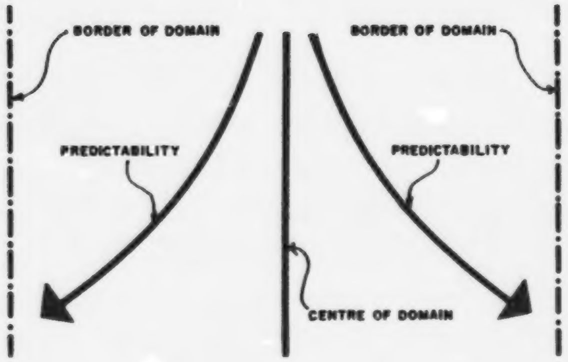

BORDER OF DOMAIN
BORDER OF DOMAIN
PREDICTABILITY
PREDICTABILITY
CENTRE OF DOMAIN

FIG. 12

As a result, the centre of a domain is the most predictable area. Any system whose survival depends on maintaining an inner status quo would have a better chance if it were located in the centre of the domain.

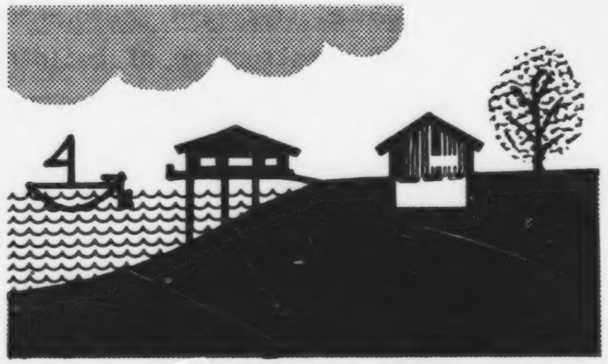


FIG. 13

Moving the location towards the periphery results in less predictability (safety) and thus there is an increased need for more engineering ingenuity and/or there is a higher energy penalty.

A human shelter in a conventional setting is subject to three basic natural elements:

- a more or less "constant" base - topography;
- a fairly "constant" force - gravity;
- a periodic exposure to the sun's radiation (and to other elements put into motion by the sun).

Coping with gravity at a minimum cost (minimum energy) is an exciting subject for further research.

Thus, the focus of our investigation will be aimed at the remaining two elements: topography and the rhythm of the sun's exposure.

COMPOSITE FORCE ACTION

We have established that our aim is to achieve a steady state within a building. It has to be done in an environment which is continuously changing. Changes in the environment are complex processes; the composite force action of the sun, wind, and water produce a cumulative effect in a given area. Ideally, we should be able to decode this cumulative effect of the composite force action and to arrive at its individual components, such as the speed, the direction and frequency of the wind, the amount of sun energy received, the ambient air temperature, etc.

Once an individual component is isolated, it could be measured. There would be two kinds of measuring tapes used:

- magnitude and direction of those components related to the static environmental forces; and

- variation, interval and range of components related to the dynamic environmental forces.

We shall start with a systematic and careful description of a sufficiently large yet manageable area such as (the political boundary of) a region. Later, we will translate these environmental component measurements into useful guidelines for the construction of building forms as well as for partial or complete neighbourhoods.

The dynamic interaction of environmental forces and their cumulative effect still eludes our full understanding. However, this should not prevent us from navigating with a reasonable degree of accuracy. In our last report ("Planning for Low Density - A Solar Approach"), we have, in the opinion of our reviewers, successfully attempted to develop a format for a general description of a given area. The selection and synthesis of individual environmental commponents was based on our professional intuition and the anticipated needs of practitioners rather than on the rigours of scientific inquiry.

THE ECOCHART

The "Ecochart", as we call it, is in essence an area specific ecological descriptor. It is a poster sized chart divided into two parts:

- The first represents the topographical variations with all the natural and man-made objects included (components related to static environmental forces);
- The second part is an assembly and tabulation of local climatic data in a digest form (components related to dynamic environmental forces). Although far from being all inclusive, it makes it possible to understand the dynamic variations of a given area at a glance.

Even this fairly simplified description of a complex and dynamic reality is a tool of great value to an architect, urban planner, and engineer. The Ecochart is of particular importance during the initial stages of the design process. This is the time when basic strategic decisions are made. Changes in basic strategies could be costly at a later date.

In summary, the Ecochart indicates the relationship between a number of environmental stresses and how the resultant composite force is made up. Furthermore, it makes it possible to compare different areas and evaluate their suitability (economy) for a variety of developmental options. It is surprising how much difference there can be in areas only a few miles apart.

We included a mildly improved version of the Ecochart in Appendix "F" of this report.

LAND FORM DESCRIPTION

In order to arrive at some comprehensive set of design guidelines for the construction of man-made forms, we have to understand the interaction between environmental forces and land form better.

Topographical contours are an established medium for conveying information about the land form and its height variation. Contours are very convenient and useful for many purposes. However, our ecological strategy requires a better tool.

Our task is to translate conventional topography into a land form description which would indicate its relationship to other (dynamic) environmental forces, in particular to the prime mover, the sun.

SLOPE GRADIENT DESCRIPTION

One method is particularly suitable for this purpose. An area described by standard topographical contours is divided into a square grid. The size of a basic square is arbitrary and could change from area to area. How to select the most convenient size of the basic square will become obvious during the course of our explanation.

The next step is to proceed from square to square and observe the drama of the land form. If very little is happening, meaning that the land is flat (for example zero degrees or less than one degree), we do nothing and continue to the next square. However, if there is a slope, we divide the basic square.

The subsequent division of squares results in a scale where the different sizes of squares would represent different degrees of slopes.

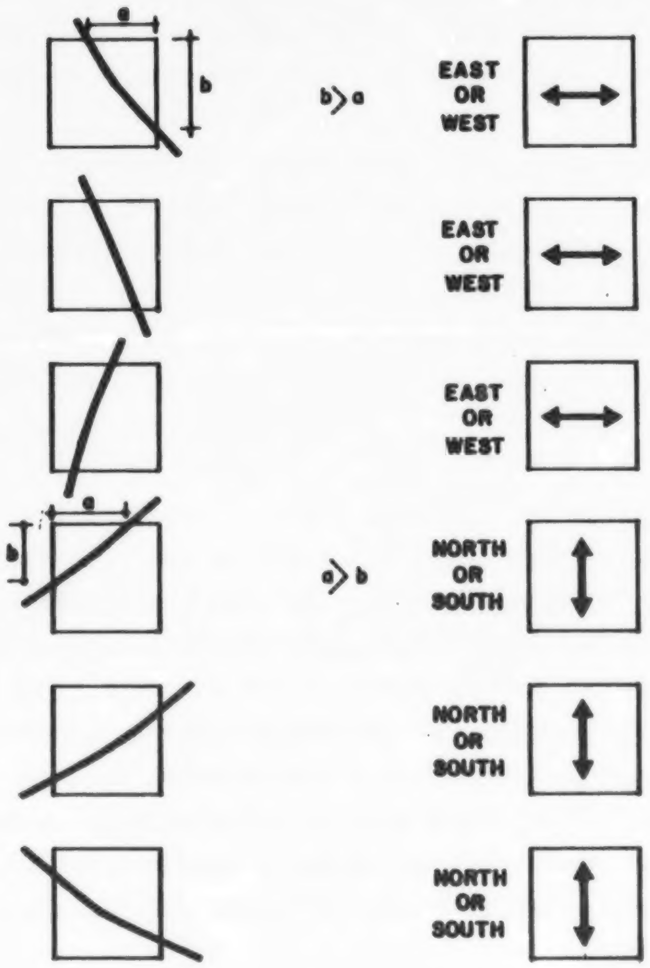
By this means we have in fact completed the transition of the contour map into a different method of land form description. The third step is to relate the land form to the dynamic environmental forces. This will be achieved by the slope orientation description.

SLOPE DESCRIPTIVE MATRIX

Our new "map" is a mosaic of squares. Each square carries information about the magnitude of slope variation. In the next step, we shall add information about the direction of the slope. The simplest way is to take each square in turn and observe the behaviour of the intersecting contours. The following table shows how to translate the actual slope into a nominal slope within each square.

An arrow is a convenient method of indicating a slope. It is even more convenient to attach a shade or colour to each direction. For the purpose of this report, we selected the following shades and colours:

DIRECTION OF SLOPE	SHADE	COLOUR
SOUTH	0 % letratone	magenta
FLAT (NO SLOPE)	10 % letratone	violet
WEST	30 % letratone	purple
EAST	50 % letratone	lavender
NORTH	100 % letratone	aquamarine



ACTUAL SLOPE to be translated into **NOMINAL SLOPE**

a
b
b>a
EAST OR WEST
EAST OR WEST
EAST OR WEST
a
b
a>b
NORTH OR SOUTH
NORTH OR SOUTH
NORTH OR SOUTH

Fig. 14

The slope directions were arranged in a particular order: S, F, W, E, N. This order also expresses the degree of sun energy receivership:

1. S MAXIMUM ↑
2. F
3. W
4. E
5. N MINIMUM

NOTE: East and west is a mirror image of the same sun path geometry. However, the morning sun is struggling with a dip in the night temperature and other associated obstacles, such as vapour in the air, etc. The afternoon sun is shining on an already preheated environment. Therefore, due to its morning thermal storage, the west has a higher position in the hierarchical order cf sun energy receivership. Those who live in houses with windows facing both east and west would no doubt confirm our observation.

LAND AS A NATURAL SOLAR COLLECTOR

The result of our land form description exercise is a portrait of a given area as a natural solar collector. We observe that different parts receive different amounts of solar energy. The size of a square tells us the severity of a topographical change and the shade/colour indicates the orientation. Furthermore, all the information could be easily expressed in numbers.

For a land economist, planner, developer, and architect, the general description of a given area is of profound importance. Since it consists of data related to static as well as to dynamic environmental forces, many strategic decisions can be defended with crystal clear logic.

Such strategic decisions could involve the selection of any area for a particular land use, an economic comparison of two or more areas, the location of different land uses within a given area, etc. In a situation where the decision for a particular land use was based on reasons outside the ecological context, the penalty, in terms of energy consumption and cost, can be calculated.

INTERPRETATION AND APPLICATION

Let us suppose that a single family detached house is the only building form allowed in planning a new residential neighbourhood. If the individual houses are to be energy efficient and take advantage of local environmental conditions, especially the sun, then the most advantageous locations would be southern slopes and flat areas. Following the instructions of our land form description, we would propose minimum densities on northern slopes. In certain cases, such as on steep northern slopes, this scheme might lead to other energy penalties; for example, to longer roads and services. Thus, when the maximum permissible lot size limit is reached, we would have to proceed with a different strategy.

Houses built on northern smaller sized lots would have a limited ability to utilize any direct exposure to the cylical forces of the sun. A house which requires almost no energy input to offset diurnal and seasonal variations is a superinsulated house. The superinsulation trick is based on the fact that a normal level of internal metabolism can generate enough heat to secure thermal equilibrium without any additional energy input. In other words, the heat produced by the human body and home applicances is sufficient to eliminate any kind of furnace, including a solar one. All we have to do is to keep the heat in. Superinsulation does exactly that.

It should be pointed out, however, that the metabolistic heat harnessing concept is still in its development stage and has its vested limits. We are dealing with a fairly complex machine and any wholistic energy accounting must include the amount and cost of embedded energy used in manufacturing the insulation, the mechanical devices and the special building components.

The mysterious behaviour of water condensation in roofs and walls makes us wonder if such Star Trek thermal performance standards should not also demand Star Trek materials and construction techniques.

A closer scrutiny of the superinsulation concept would uncover the fact that much of the heat which is generated within a house is due to the energy inefficiency of a particular appliance or mechanical device.

It appears that if the process of energy conservation and energy efficiency continues at its present speed, designers of superinsulated houses will soon be left with nothing more than the warmth of a burp.

However, many of the technical, technological and material problems which are associated with the design and construction of superinsulated structures are in fact of a minor nature and with extensive experimentation should be overcome within a few years. A superinsulated house is a marvelous conceptual answer to our excessive energy consumption problems. Undoubtedly, the superinsulated house is here to stay.

In our last "Planning for Low Density - A Solar Approach" report, we were criticized for our naivete in believing that a zero heating bill house could be constructed in Southern Ontario.

Well, it appears that such a house can be built within a few years. Most likely, it will be a passive solar/super insulated hybrid, with intermediate thermal storage, if our interpretation of the Ecochart is correct. Furthermore, we are even more optimistic or naive this time. We believe that such a Southern Ontario, zero heating bill house will be developed and promoted by the construction industry.

Thus, a superinsulated house might be one of several architectural/engineering answers to steeper northern slopes. We can also conclude that this demonstrated relationship between land form and building construction and design clearly indicates an urgency to mend the quarter century communications rift between associated professions.

Let us suppose that the planner would be at liberty to use a mixture of residential densities within our hypothetical neighbourhood. Higher densities, structures which accommodate two or more families, are inherently more energy efficient than detached single family houses. The surface/volume ratio of a larger structure is more favourable. As a result, the structure is less susceptible to environmental stresses caused by diurnal and annual variations. Furthermore, a multi-family building (building of larger volume) generates higher internal metabolism which in turn lessens the expense of maintaining the necessary thermal equilibrium throughout the year.

In such a case, a planner might conclude that, for maximum energy efficiency, the northern slopes should be the location of the highest permissible densities.

In the absence of a wholistic energy accounting system, the design process is still a combination of both art and science. Thus we can imagine a circumstance when it might be most advantageous for energy efficiency as well as for the logic of the overall neighbourhood layout to make northern slopes part of an open space system designed for winter recreation.

Undoubtedly, the Ecochart and Land Form Description are tools of profound importance. Yet there is still one more use that should be mentioned.

In the past, it was common practice to do everything possible to reduce the individual differences between lots to a bare minimum. There were a few standard widths and depths, and the only real excitement was a pie-shaped lot on a dead end street. From the point of view of aesthetics, function and economy, airfield flatness was considered an unsurpassable ideal. Bulldozers were kept busy to create this ideal.

Our Land Form Description tells us about an area and its connection with environmental forces. We are in fact looking at a picture of a natural solar collector.

The different degrees of sun energy receivership hint at opportunities for energy efficient land utilization. At the same time, we realize that the natural solar collector was not created with our contemporary human needs in mind. Opportunities are usually more than offset by constraints. The reality is messy.

A close scrutiny of the Ecochart and the Land Form Description might show that a certain readjustment in the land form could result in greater energy efficiency for a developed area. In fact, we can design an ideal energy efficient landscape. If the cost of fuel justifies it, we should keep bulldozers busy to create this ideal.

GOLDEN TIES

Living on a sphere has an inevitable consequence: exposure to the rest of the universe. The relationship between terrestrial life and the movement of the heavenly bodies has been observed since the dawn of human history. The survival of ancient nomads, farmers and mariners was directly related to understanding celestial mechanics. Modern man did not shake off these ties. Our connection with the rest of the universe has only been slightly obscured recently, mostly by our perception rather than by the facts of the matter.

The energy devouring mode of living eradicated our intimate relationship with the natural forces. The gentle art of sailing through the natural environment evaporated from our culture. Big mechanical systems made it irrelevant whether the sun shone, for how long, and from which direction. We were environmentally independent.

The houses and communities which we built in the recent past are not tethered by golden ties to our solar, life sustaining furnace. In this chapter, we shall investigate how to renew these golden lines between man-made form and the sun.

SKYDOME

To an observer facing south, the sun would appear to be moving from east to west. The path which the sun is following has three important points:

sunrise - the lowest point

midday peak (noon) - the highest point

sunset - the lowest point

All three points are continuously moving throughout the year. If we can imagine ourselves standing in the centre of a transparent dome, we would be able to see and to record all the sun's skypaths throughout the year. We would observe that all the lines representing the movement of the sun would take place between two extreme situations: the sun's path on June 21, the longest day of the year, and the sun's path on December 21, the shortest day of the year.

Thus we arrive at a strip which can be drawn on the wall of our "Skydome". This model represents the most important part of the sky for a person or a system located in the centre of the Skydome. In the absence of any other source of energy, any obstruction of the sun is no longer just a minor nuisance but could be a matter of life and death.

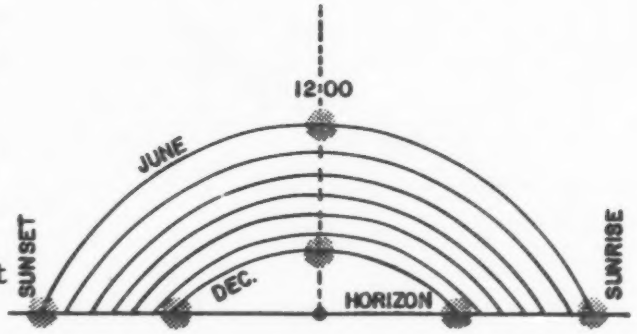


FIG. 15

SKYWINDOW

We have determined that the sun with its continuous movement makes a part of the sky tremendously important to a living system on the earth's surface. If such a sky strip were an individual's right and any obstruction prohibited, then we would completely eliminate our side neighbours. We would be allowed to build only behind and not beside each other.

Fortunately, the value of sunlight, in terms of energy, differs throughout the day. Due to the angle of incidence and the presence of the atmosphere, the most valuable sunlight for any practical consumption is located close to the peak of the daily sun path.

Over years of in-depth research, it has been established that the sunlight with the highest energy density can be harnessed between 09:00 hours and 15:00 hours. If this convenient limitation is drawn on our Skydome, it leads to the concept of a "Skywindow".

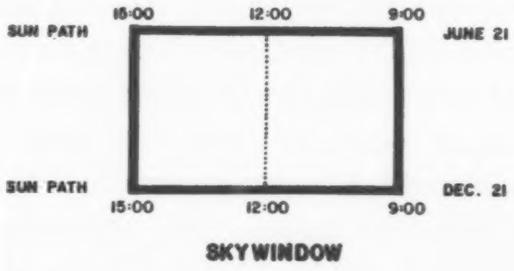


FIG. 16

In essence, a Skywindow is an opening in the Skydome. The geometry of the window will guarantee the sun's direct access within a stipulated time frame throughout the day and throughout the year. The Skywindow is a physical expression of our right to sunlight and can easily be translated into the legal language of our municipal by-laws.

SOLAR PYRAMID

A Skydome with a Skywindow opening could serve not only as a passive educational tool or a legal expression of our right to sunlight, but it can also be used as an active and very useful design instrument.

The Skydome as a design tool acts in a similar fashion to a television picture tube. Each position of the sun in the sky, within a given time reference (Skywindow), projects a dot on a projection screen; in our case, on a horizontal, flat (zero slope) surface. With some stretching of the imagination, we can see a three dimensional product of this experiment.

The Skywindow generates its two dimensional projection on a horizontal surface. However, if we consider sunlight as lines, we can produce a volume: a "Solar Pyramid".

The construction of a Solar Pyramid is very easy with the help of Shadow Templates (see Appendix "E".
The base of the Solar Pyramid is generated by a diurnal and annual composite shadow pattern of a pole. The height of the pole is equivalent to the height of the Pyramid as shown on page 84

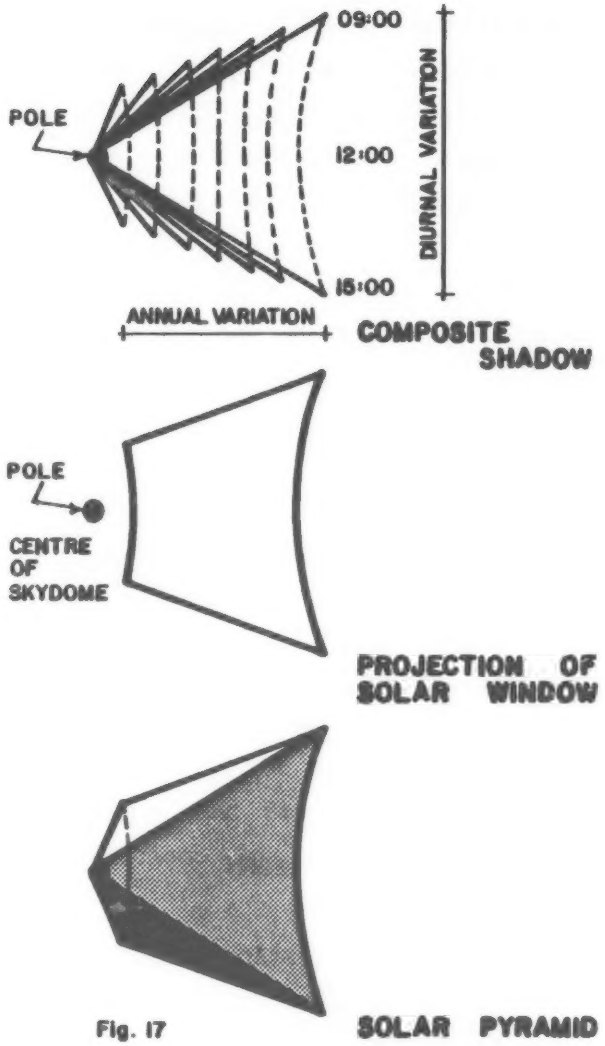


Fig. 17

The Solar Pyramid is the basic building element for the construction of a maximum developable space, an envelope.

SOLAR ENVELOPE

A Solar Pyramid can represent the shape of a building. Such a building would have a predictable (definite) impact on its surroundings. It would not cast shadows on its neighbours between 09:00 and 15:00 hours.

However, what is permissible by these behavioural limits might be rather cumbersome to construct. Thus, the actual building usually takes conveniently less space than that which is stipulated or allowed by the geometries of the Solar Pyramid. Thus, the Solar Pyramid becomes a representation of a maximum developable space. Since this volume was generated by a composite projection of the sun's rays, we call it a Solar Envelope.

In the real world of planning and design practice, the maximum developable space is usually dictated by the size and shape of a maximum permissible impact area. Such an area might be oddly shaped and it might be impossible to superimpose it by a single projection of a Solar Pyramid no matter how its height is adjusted.

Obviously, the maximum developable space, the Solar Envelope, must be generated by a composition of several Solar Pyramids. This technique is simple and is described on page 86.

SOLAR ENVELOPE AND LAND FORM

Solar Envelopes are carved out of invisible urban space. They can be filled, partially or fully, with a building. To comply with the current professional apartheid, we propose that the construction of the Solar Envelope, the maximum developable space, be the prime responsibility of the urban planner.

So far, our form generation concepts were presented as if we were developing an abandoned airfield. Zero slope situations are actually quite rare. Even the seemingly flat Hamilton upper plateau is composed of rather dramatic topographic variations, as shown in our Land Form Description exercise. Thus, the maximum developable space has to be constructed in conjunction with the topography. In planning and design practice, Solar Envelopes are generated by both the sun's rays and the land form (Solar Pyramid base metamorphosis, see page 84).

At first glance, the task might appear to be a frightening exercise in descriptive geometry. In fact, it is fairly simple: Land Form Description is a planning tool. It recognizes five nominal categories of slopes (S, F, W, E, N), which is also the highest degree of directional variation used by the planner. Our Shadow Templates were specially designed for these five nominal slope orientations. Once the concepts of the Skywindow and Solar Pyramid are understood, the construction of a maximum developable space, the Envelope, for any nominal slope direction, becomes a kindergarten task.

GENERATION OF BUILT FORM

The Solar Envelope stipulates the maximum volume of urban space which is permitted to be filled by a building. The dimensions and shape of a Solar Envelope is a product of the area of influence, and the interaction between the sun's rays and the land form. In an extreme situation, it could be completely filled by a building.

In reality, however, an architect would use the Solar Envelope as a general description of a built form, one specifying building height and area of influence.

The format of this report does not allow us to elaborate on the process of built form generation in detail. There are, however, two associated concepts of built form design which should be of interest to an urban planner.

We established that a Solar Envelope completely filled by two-by-fours, concrete, bricks and mortar would result in a building which would have a predictable impact on its neighbours within a stipulated time frame (within the size of Skywindow). At the same time, a building of such shape might be costly to build and also such a shape might not be the most efficient in terms of energy receivership.

Traditionally, the designer of a building works out a compromise between two sets of considerations: providing a comfortable space for human activities and protecting them against outside environmental forces. The shape of a building is the result of these, in many cases, conflicting requirements.

A dramatic illustration of this is an aircraft: the ingenuity which is necessary to make it into a workable whole - the outside, streamlined shape and the inside space for human use. As we all know, the result is occasionally less than perfect. A taller than average man would confirm the difficulties involved in standing in the washroom, bending over backwards to accommodate the curvature of the streamlined aircraft exterior.

The designers of buildings admittedly face somewhat less complex tasks than the designers of airplanes. However, if we wish to design a building which would simply, by virtue of its form and shape, be able to secure its internal thermal equilibrium, then referring to aircraft design problems is not totally out of context.

SURFACE-VOLUME RATIO

Every building is subject to a composite of environmental forces. The meter of their susceptibility is the surface-volume ratio. The less surface that is needed to enclose a given volume, the easier it is to handle outside stress. The classic illustration is an expanding cube. A comparison of the susceptibility to environmental perturbance of different geometrical shapes is shown on page 105.

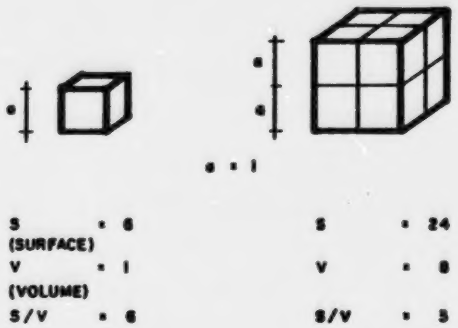


FIG. 18

The conclusion for a building designer as well as an urban planner is obvious: buildings with larger volumes provide an opportunity to increase internal metabolism and, at the same time, their surface is a relatively smaller target for external forces.

Obviously, this improvement in surface-volume ratio cannot continue indefinitely because there is, as one may expect, a limit. In a wholistic energy account, we have to consider energy penalty in terms of the cost of manufacturing special building materials (to cope with the gravity) and the cost of manufacturing and maintaining the complex mechanical devices needed for human occupancy, for example, elevators.

SUN ENERGY RECEIVERSHIP

The second important building design consideration which an urban planner should be aware of is related to the building receivership of sun energy.

A building constructed within a Solar Envelope could be a more or less efficient solar collector. This depends on the shape. Under the continuously moving sun, some shapes receive different amounts of sun energy at different times of the day or at different times of the year. An illustration of these sun energy receivership variations is shown in Appendix "B".

The described relationship between different forms and sun energy receivership is based on the "sun's point of view". Literally it means "how the sun sees the object", or how much of it it sees. The size of area "seen" by the sun is directly related to the receivership of sun energy.

Another way to describe this sun/form relationship is to say that the degree of receivership of sun energy is in direct proportion to the area of sun's rays obstruction caused by a given form at a given time.

Both definitions mean that we have to construct a projection (a shadow) of a given form on a screen which is perpendicular to the direction of the sun's rays.

The first and obvious step in utilizing this methodology is to evaluate commonly used built forms, and wherever possible to improve their shape and orientation.

However, we would like to propose that this passive evaluation tool be used as an active design tool. This means that the designer would specify the need for sun energy receivership (annual and diurnal) and then he would search for acceptable (suitable) forms.

Interestingly, this derivation of optimum built form from the sun's rays could be an equally important design tool for an architect as well as for an urban planner to plan and design large urban areas.

We must begin by taking note of the countries and climates in which homes are to be built if our designs for them are to be correct. One type of house seems appropriate for Egypt, another for Spain . . . one still different for Rome, and so on with lands and countries of varying characteristics. This is because one part of the earth is directly under the sun's course, another is far away from it, while another lies midway between these two . . . . It is obvious that designs for homes ought to conform to diversities of climate.

Vitruvius, Roman Architect
1st Century B.C.

DESIGN OF A NEIGHBOURHOOD

The ecological approach to energy efficient design and planning was based on the premise that man-made systems, such as buildings or communities, should be constructed with respect to the cumulative effects of natural forces, particularly with respect to the sun.

Similar to all living systems, each building has to maintain its internal equilibrium; if placed and constructed in disrespect of its ecological context, compensation has to be made in terms of higher energy input. It has been established that this is not a sound economic proposition at the present time.

Thus, the major challenge of energy efficient urban planning is to provide a spatial framework within which an individual building can maintain its internal equilibrium at a minimal cost.

Suppose there is a map of a virgin land on the board, ready to be seduced by the strokes of a planner's master pen. What has to be done, what steps should be taken, to arrive at an energy efficient neighbourhood plan?

First, a neighbourhood should be considered as a system on its own. It has its internal structure and composition and a relationship between its individual parts, its own metabolism, and associations with outside natural and man-made systems.

In this report, the designer of a neighbourhood is undertaking the same challenge as the designer of a building or of an aircraft. The actual design process has to commence from two sets of considerations:

- the user's physical and mental dimensions, his needs and activities;
- the opportunities and constraints related to the outside natural and man-made environment.

The aircraft design example dramatically illustrated that a reconciliation between conflicting objectives is not always easy to achieve and that the resultant design is often less than a perfect compromise.

If the two sets of requirements are taken separately (in isolation), they would most likely lead to two drastically different spatial answers; design is still more art than science. The great designers can attack the problem from both ends simultaneously.

Because of the obvious limitations of this report, we shall proceed in sequence and begin the description of the design process from the point of the surrounding environment. We shall identify the design opportunities and constraints set by natural forces.

INTERACTION BETWEEN ENVIRONMENTAL FORCES AND LAND FORM

Any sensible neighbourhood design effort based on the previously described approach must commence with learning and fully understanding the local situation. The most convenient tool is:

- 1. The Ecochart

The construction of the chart is based on mezoclimatic data (related to the size of our region). Although microclimatic conditions within the neighbourhood or subdivision may vary, the Ecochart represents a fairly accurate environmental framework. The data related to the sun (azimuth, altitude, hours of sunshine, etc.) is of particular importance to a neighbourhood designer in the very initial stages. The composition of environmental forces can be significantly different from area to area and the basic design and planning strategy has to be based on an interpretation of the local environmental chemistry.

Mistakes in the initial stages could be irreparable and unrectifiable at a later date, and thus possibly very costly. For example, the number of sunshine hours in the winter has to be evaluated in conjunction with the winter temperature profile and the topography.

Even on a very trivial level, the gravity of strategic planning decisions can be easily demonstrated. Let us assume that in our given area, a neighbourhood, clouds frequently obscure the winter sky. There is only a limited number of sunshine hours available during the three coldest months of the year. A planner might consider the following options:

i) It would be necessary to build all buildings as extremely efficient solar energy harnessing machines. The most advanced equipment, working even under cloudy skies, would be incorporated. Sun access must be guaranteed to every structure.

ii) Passive solar houses would be equipped with intermediate thermal storage to bridge the times when the sun is obscured. Sun access is still very important.

iii) All houses would be designed and constructed as airtight, superinsulated structures; the internal metabolism would be the only source of heat. Thus, sun access might be helpful but not an absolute must.

iv) Underground development would utilize the buffering effect of earth cover. Sun access is of advantage but we can do without it.

v) Conventional houses would maintain their thermal equilibrium exclusively by outside manufactured energy. Sun access is of little importance.

This list of options is, of course, totally isolated from others of equal importance. The fact is that a neighbourhood design concept cannot be determined solely by the hours of sunshine.

The relationship between the composite forces of natural variation, the land form, and a multitude of inner and outer factors would result in a mould for casting a new neighbourhood.

We shall proceed step by step.

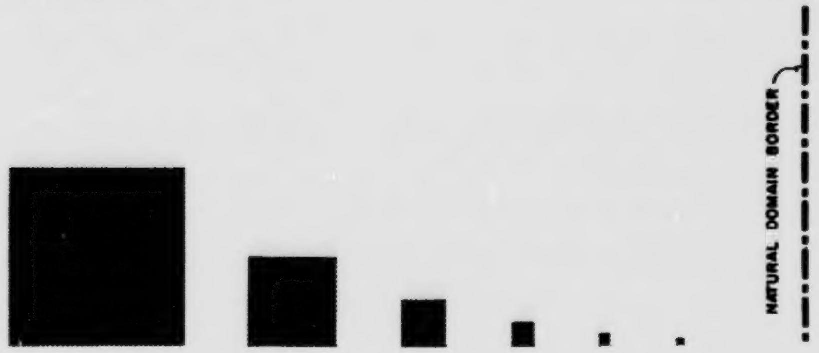
- 2. The Slope Gradient Description (page 75)

The method of illustrating topographic variations based on a square grid was described in the previous chapter. This schematic portrait of ups and downs indicates the possibility of energy penalties with respect to the slope variation.

The size of a square is related to the topographical change. The smaller the square, the more dramatic is the change taking place. Furthermore, the size of a square is related to the potential size of a building lot as well as to the potential size of a building itself.

Very small squares usually represent the boundary of a natural domain (page 24), while large squares might be located both in the centre as well as on the domain's periphery.

The following is an attempt to summarize the set of instructions derived from the slope gradient description:



- greater predictability	- conditions less predictable
- more potential for building options	- less potential for building options
- larger buildings	- smaller buildings
- greater level of complexity and diveristy	- lower level of complexity and diversity (simpler buildings)
- higher level of organization	- lower level of organization (small independently acting parts)
- physical environment encourages development	- physical environment limits development
- variety of activities (high intensity of use)	- lack of variety of activities (low intensity of use)

NATURAL DOMAIN BORDER

- maturation through transformation to a greater level of complexity and diversity (interconnection between buildings, potential for increased mass, more favourable s/v ratio, increased metabolism and less susceptibility to environmental perturbance)	- low level of transformation over time

NATURAL DOMAIN BORDER

Finally, it has to be stressed that the Slope Gradient Description is of great assistance in calculating the cost/benefit of land improvements by bulldozer.

- 3. Slope Orientation Description (page 28)

While the Slope Gradient Description informs us of land form stress in terms of variation, the slope orientation description reveals the relationship of the land to the cyclical forces of the sun.

Thus far, the neighbourhood designer was able to develop some broader schematic land use alternatives based on a description of limitations and opportunities. The slope orientation description is another tool to help crystalize the concept.

Our design approach distinguishes five nominal slopes: south, flats, west, east and north. This order also represents the gradient of sun energy receivership, from the maximum to the minimum. A slope orientation chart carries an important message to a neighbourhood planner: the lower the energy receivership, the greater is the need for outside energy input and/or for the retention of metabolistic heat.

A synthesis of both the Slope Gradient Description and the Slope Orientation Description, together with the Ecochart data, makes it possible to make a basic land use decision. Furthermore, the planner should be able to understand the consequences of his/her deicisions and be able to discuss trade-offs intelligently. With the assistance of a computer in the near future, a planner should be able to express his/her arguments in dollars and cents.

At this point the neighbourhood is still in a very preliminary stage. However, an understanding of the reality has already been developed and there is also the anticipation of a faint outline of the solution.

We have a glimpse of the sonar image of a womb.

INTERACTION BETWEEN BUILT FORM AND BUILT FORM

If any object is so placed as to take the sunshine from a heliocaminus, it must be affirmed that this object creates shadow in a place where sunshine is an absolute necessity. Thus it is in violation of the heliocaminus' right to the sun.

Ruling of Judge Ulpian,
Roman Lawyer, 2nd Century A.D.

The process of developing a neighbourhood design as described thus far is a simplified and compressed version of the actual planner's line of actions. Our proposition of an alternative design approach is unorthodox and demands repetitive explanations and illumination of unfamiliar procedures. The ultimate objective is to ensure that rejection or acceptance will be based on a full understanding of this new approach to neighbourhood planning and design.

The next step on a planner's agenda is to address the third dimension.

Buildings constructed during energy devouring times are not planned or located in relation to the dynamics of their natural surroundings. The shape of an individual building is the product of a variety of pressures such as the resale value, the commercial value of the land in a particular area, the size of the land, building codes and other restrictions.

The relationship between a building and another building is therefore a product of our inadequate accounting system, our setback by-laws and of course, in many cases, a product of pure accident.

A planning system based on an understanding and insightful manipulation of local environmental conditions makes it possible to plan, shape, and situate a building in a totally different manner: the proposed planning framework would allow a mitigation of seasonal and diurnal variations and thus would replace, limit or reduce the need for mechanical, cooling/heating, energy devouring systems.

This three dimensional planning will be based on the premise that any building built in the neighbourhood would be in harmony or in complementary relationship with its natural and man-made surroundings. It is the planner's role to develop and to stipulate the maximum physical limits of this performance specificiation. This is done by the constuction of a maximum developable space - the Envelope.

The size and shape of this utmost volume is derived from the size and shape of the impact (influence) area. As we have already specified, one building must not negatively influence, i.e. distort the thermal equilibrium of, another building. This, of course, means that the Envelope must, in fact, also be derived from the geometry of the diurnal and annual rhythm of sun.

This requirement would be fulfilled by the generation of a Solar Envelope (page 37). In digest form, the process goes like this:

A Skydome is an imaginary transparent dome. To an observer in the centre, it is obvious which part of the sky is most important if survival depends on sun energy receivership. This area of the dearest piece of sky has dimensions based on diurnal (in our case 09:00 - 15:00) and annual (June - December) variations. We call it a Skywindow.

A Skydome with its opening can serve as a design tool. Elevated from the horizontal surface, the Skydome begins to function as a sort of "lens", projecting the Skywindow. A projection of the Skywindow on a horizontal (or tilted) reference plane constitutes the base of a Solar Pyramid. The centre of the Skydome is the top of the Pyramid. The height of the Pyramid is equivalent to the distance between the base (reference plane) and the centre of the Skydome. We call it a Solar Prick (page 85).

The Solar Pyramid is the basic building block of a Solar Envelope. For drafting convenience, a set of Shadow Templates has been developed (Appendix "B"). In the absence of computer graphics equipment, using Shadow Templates is the simplest and fastest method for determining the composite (diurnal/annual) shadow pattern of any object and for constructing Solar Envelopes.

The first step a neighbourhood designer has to take is to construct a Solar Envelope for the whole neighbourhood. We shall call it the "Super Envelope".

THE SUPER E CONCEPT

The starting point for any Solar Envelope design is the size and shape of the impact area (page 86). Once we have established how far shadows of future buildings may penetrate beyond our boundary, we can calculate the maximum permissible height of buildings. In other words, we have the base of the Super E (page 88).

One can imagine an extreme case where such a volume might be completely filled with a building. It would be a rather large structure, echoing Soleris' visions, and would probably accommodate most of the existing population of the City of Hamilton. However, as long as it is confined by the physical restrictions of the Super E, it would not affect adversely the thermal equilibrium of buildings in adjacent neighbourhoods.

Even in a conventional scale neighbourhood, the construction of the Super E is an important and useful step. It indicates the permissible height of buildings and structures erected along the perimeter of the neighbourhood.

Since our goal is to develop a healthy ecological symbiosis of all buildings constructed within our neighbourhood (and within the limits of the Super E) the spatial framework must be further developed.

The spatial specifications for individual buildings can be achieved by a system of smaller envelopes. The Super E has to be broken down to the scale of anticipated development.

Subdividing the Super E into a system of Solar Envelopes which would provide spatial specifications for an individual building can be achieved by a variety of methods.

One can imagine continuously carving, cutting, and splitting until we end up with a sort of three dimensional web. It might remind some of the cracked ice in a drink on a hot, sunny afternoon.

In a scale model, the Super E would appear sitting over the landscape like a giant crystal, built out of an uncountable number of transparent solids of odd shapes and dimensions. The neighbourhood planner can look into this marvelous crystal formation and observe, like in a fortune teller's ball, the past, the present and, of course, a plethora of potential futures.

He would see small houses, widely spread apart or clustered, located on a variety of street patterns; he would see buildings of different sizes and shapes sheltering people's activities in different locations and at different times. He would see construction, destruction and relocation, structures rising, changing their forms and their purpose for existence. He would see the spatial and temporal dimensions of a human settlement, the growth, the process of maturation.

However, these spatial alternatives, metamorphosing over time, would not be the product of chance; the logic of the subdivided Super E commands all structures to have one common denominator and underlying discipline: all the man-made structures must have a precisely defined relationship to the natural environment as well as to each other.

Naturally, such a sneak preview of time/space opportunities might be potentially overpowering. To appreciate fully the Super E as a design tool, we need to glance back a few pages.

FROM INSIDE OUT - THE INNER LOGIC

We have established that our neighbourhood design process must be exercised in two directions:

- from outside in (--►o◄--), and
- from inside out (◄---o--►).

This is precisely the way living systems are "designed" in nature. Thus, we can observe animals and plants of different sizes and shapes pursuing different survival strategies in particular environmental domains.

Similarly, in an attempt to design the best possible house, an architect would imitate the natural design process. His attention would be directed towards the internal environment, organizing spaces for a variety of human needs and activities, designing a logical system of rooms of different sizes and shapes (◄---o---►). At the same time, he would take into consideration the external environment (---►o◄---). The construction system would take care of gravity, and the outside walls and roof would absorb, reflect or filter external dynamic forces. Within the constraint of existing and affordable materials and techniques, the form of the house would be finalized. Special attention would be given to particular stresses which environmental perturbation manifests itself in. Thus, according to the natural domain characteristics, the completed house would withstand snowload, windload, and it would be able to cope with extreme heat, cold and rain, etc.

If designed within the framework of our ecological, energy conscious planning approach, its success would be measured by the reduced need for imported energy to secure internal thermal equilibrium.

We have also mentioned that if we were designing for exotic domains, if we wished to accommodate humans in a particularly hostile environment, all efforts in the pre-design stage must be directed towards understanding the physical location and forces involved.

In these situations, the shape, form and size of human shelter is usually dictated, or "designed", by the stress of external forces. But even in our relatively hospitable climate, the absence of manufactured and delivered energy, the stresses of annual and diurnal variations, would significantly influence the final design. If a shelter is to respond to environmental variations by virtue of its form, designers must understand well the characteristics of natural domains and must be well equipped with new techniques to cope with this emerging challenge.

Along the same principles, we wish to propose that a neighbourhood is a man-made system, similar to a human shelter or similar to a living system. When peeping into the Super E, we realized that a neighbourhood can potentially grow and restructure itself into a single building. Although such an evolutionary possibility should not be rejected outright, we shall deal with a neighbourhood as presently understood and within our cultural context.

Every neighbourhood has its own parts, sub-systems and elements, its communications network which binds all components and fractions into an organic whole. Similar to a building (shelter), it has its own metabolism and its survival depends on its success in maintaining its own internal equilibrium.

On the other hand, there is a profound difference between an individual structure/building/shelter and a neighbourhood as we are used to. The difference lies in the degree of autonomy of individual components. The neighbourhood system is composed of a relatively loosely connected matrix or network of quasi independent parts.

During the energy devouring times, this very independence was unreasonably amplified. As a consequence, professional planners had to heroically struggle for a wholistic approach to neighbourhood design. Success was limited, however. The temptation of ad-hocery was irresistable.

We suggested that the role of an urban or neighbourhood planner is to design a spatial framework within which individual buildings can maintain their internal steady state at a minimum cost. We have described all the steps which a neighbourhood planner must take in the process of designing from outside in (---►o◄---). Although the composite impact of natural forces is still slightly mysterious and cannot be exactly calculated, the design process from outside in is based on logic and reason. Many environmental stresses can be objectively measured and design decisions can be substantiated by verifiable facts.

Unfortunately, the design process from inside out (◄---o---►) presents a totally different set of challenges. The present, typical layout of a residential neighbourhood is the product of a large number of compromises between large number of parties over a large span of time. Some spatial arrangements are based on the cold facts of economy, the roots of which can sometimes be traced to the other side of the globe; other neighbourhood planning principles are derived from the obscure mechanics of the human brain. Categories such as resale value, often presented in economic terms, are born purely in the human mind. A close scrutiny would show that the secondary human needs, e.g. the facade of a house, overshadow the primary human needs, such as convenience and protection from weather elements.

Builders and subdivision developers are very much aware of this fact of life. Even today, after all that has been written and said about energy, the best seller in a new neighbourhood is not the energy efficient house. The selection of a house by its appearance only is, to a large degree, a heritage of the energy obese times.

It would be of great value to the improvement of neighbourhood planning and design to find out exactly how many municipal planners bought, built or moved into an energy efficient house in the last couple of years. It would be interesting to investigate why those who officially subscribe to energy conscious planning principles are not always trend setters in their own personal lives.

TEMPORAL DIMENSIONS

Our ultimate goal is to design a neighbourhood as an energy efficient system. A system which is capable of a balanced response to the variations of natural forces would utlimately result in reduced need for the import of manufactured energy.

Technically, our approach is a simple survival contest: to preserve an internal steady state in an unsteady environment.

The longer the game is played, the better the players are. Our gamble is based on the fact that the natural environment has the capacity to transform energy. As we learn the rules of this transition, our environmental gambling is more successful and we are progressively more energy efficient.

This introduces the element of time dimension into neighbourhood design. Human settlements are usually built as unfinished statements. Later, if circumstances permit, they transform themselves into higher organizational levels. Similar to living systems, they mature over time.

This is particularly important in designing energy efficient communities. Every neighbourhood which is already in its prenatal stage must be equipped with instructive mechanisms for growth and maturation. At the very least, it must be assured that opportunities for future adjustments are not blocked.

A conventional neighbourhood is a very young settlement. Unlike higher living systems, it comes into being by asexual reproduction, so to speak. Its childhood years can be described as the simple multiplication of almost identical, clone-like parts. There is low diversity, low complexity, and interdependence between individual elements and parts is minimal. Like any other child, it requires a considerable amount of energy to keep it warm and alive.

Further development is related to circumstances. If overfed and overprotected, it might refuse to mature. For the sake of preserving the comfortable status quo, it might choose to become a midget. During the energy devouring times, many neighbourhoods fought fiercely to stop the clock.

Unless artifically spoiled or arrested by unique, out-of-the-ordinary conditions, every neighbourhood would probably enter a transformation stage. This evolutionary stage is characterized by many changes. Individual parts become larger, more diverse, more complex and more interdependent. Buildings change their forms and sizes. The process towards a higher level of differentiation, complexity, and sophistication continues until it reaches a stable state, i.e. the settlement is most energy efficient under a given set of conditions.

Our conventional neighbourhood has all the characteristics of an infantile stage. The present form has been around for several decades and is firmly embedded in the public mind as a blueprint for happiness. Thus far, any evolutionary aspirations were arrested by powerful economic and cultural forces. They still have a strong momentum.

It should not come as a surprise, therefore, that a residential neighbourhood would reflect broader socioeconomic changes with a profound delay. Even the turmoil of an energy reduction flow did not mark clearly the face of the neighbourhood. Those whose livelihood depends on construction and development are continuously monitoring the public mind. The signals are not encouraging and the verdict is still the same: we must build energy inefficient houses and communities or not build at all. Try to deviate and you go bankrupt. Indeed, some already have.

For a neighbourhood planner, this slow reaction time presents a particular problem. He has to suppress his perfectly professional urge to suggest sweeping changes which would closely reflect the imperatives of our times. At the same time, he knows that a radical departure from a conventional pattern would be a transparently foolish excercise.

Having all these hinderances in mind, we propose that the neighbourhood designer proceed as follows:

1. the residential neighbourhood should be designed to be as energy efficient as humanly possible within the present cultural straitjacket;

2. there should be provisions for growth in terms of a higher level of organization;

3. there should be provisions for growth with respect to the maintenance of equilibrium at the least cost.

To identify these growth potentials in the neighbourhood area, the planner would use two sets of tools:

i) the Ecochart; a pattern of the dynamic variations of the natural forces and of the sun force in particular (Appendix "F");

ii) the Land Description Synthesis; horizontal reference, the topography, slope gradient and orientation description (page 81).

This would lead to a list of maturation options and provisions such as special Maturation Zones. Ideally, these zones would be allocated in areas which allow greater design options, a wider range of building sizes (future infills), a larger selection of modes of interaction, and permit diverse human activities (mixed land use).

DISTANCE ASSOCIATIONS

Every day, at dawn, fearless humans start a journey which they may never finish. Day after day, week after week, year after year, they perish in numbers which surpass the human tragedy of many fields of glory. But generals in operetta uniforms will not attend their funerals, no salvos, no hero signs will be put on their gravestones. There will be no medals beside their pictures on the mantlepiece. Perishing like flies into nothingness, they will be eradicated from the social memory. Still, every day they enter into the deadly game, the contest with uneven odds. These are the brave humans of suburbia, the road warriors.

What makes a human go to bettle, what makes him "yo-yo" on the highway?

For a neighbourhood planner, it is rather difficult to manipulate these dark-side-of-the-brain urges. If at all, he can do it only indirectly and very, very slowly.

The problem can be summarized as follows:

The symbiotic associations of human activities such as living, working, and recreation, in communities which were (un)planned during the energy devouring era, are all long-distance relationships. The lengthy distance between the activities which a human has to go through on a regular basis (daily, weekly, . . .) leads to high energy consumption and thus may become unaffordable in the near future.

On the other hand, we should bear in mind that some outstretched relationships might be acceptable: for example, those in which commuting can be superseded by telecommunication. However, where telecommunication cannot take place, a group of complementary activities should be physically adjacent. Physical adjacency creates a higher organizational potential, which leads to larger compact enclosures, and consequently to increased internal metabolism and to a more favorable s/v ratio.

In turn we decrease susceptibility to environmental perturbance and, in the final account, we lessen our demand for energy input.

Unfortunately, this conflicts head on with current planning practices and with the cultural momentum inherited from the past era. Under these circumstances, there are two possible actions available to a neighbourhood planner:

Firstly: - to consider neighbourhood design alternatives with shorter roads as preferable. As a result, a neighbourhood with less square footage of asphalt pavement would be given preference in the planning approval process.

Secondly: - to develop provisions for growth and maturation, such as in sizing, setback regulations, density, etc., to provide for the future accommodation of new and additional activities.

Neighbourhood energy efficiency has been presented and described as a balanced trade with the natural surroundings. But it is also a function of physical adjacency. A true energy efficient plan would make possible short distance associations among a variety of human activities.

A gradual liquidation of long distance associations would reduce energy penalties and ultimately would lead towards a new conceptual level - neighbourhood self-sufficiency.

TRADITION AND TRANSITION

The conventional neighbourhood plan is a particular response to special socioeconomic circumstances. This response was perfected by all the parties involved in the planning and development process over several decades.

Naturally, it cannot fit the recently developed set of conditions, but until new opportunities and constraints are identified and generally understood, no dramatic change can take place. The only answer to our neighbourhood planning problems is a collective answer.

Unfortunately, this requires time. For a while we are doomed to live in serfhood to obstinancy.

On the other hand, times of evolutionary procrastination allow the neighbourhood planner to concentrate on promoting changes on an incremental basis, to improve planning techniques as circumstances allow, and to educate himself as well as others. In the intermediate future, we shall not introduce a revolutionary blueprint, but rather, we will be promoting and making provisions for the maturation process.

On a more pragmatic level, in every day practice, the planner's task will be two fold:

1. Existing, already approved neighbourhood plans should be re-evaluated in terms of their capacity to allow individual buildings to maintain a thermally steady state at minimal cost.

   Furthermore, existing plans should be evaluated in terms of distance associations and physical adjacency. Wherever possible and acceptable, minor cosmetics would be made.

2. In the preparation of new neighbourhood plans, the basic, conventional layout would be partially adjusted to suit the energy/ecological planning approach. Equally important would be the incorporation of provisions for growth, transition, and maturation.

The first task is self-explanatory: the proposed, and perhaps already registered, neighbourhood developments or subdivisions would be re-assessed and possibly partially improved.

The second task is more complex. It involves three important steps:

a) The neighbourhood planner would proceed through the whole "outside-in" (---► o ◄---) design strategy, (i.e. Ecochart, Land Form Description, Super E, . . .).

b) These arrived at options of developmental opportunities would be superimposed over several (currently) acceptable alternatives of neighbourhood layouts. After an identification and evaluation of energy penalties, the best compromise would be selected.

c) Maturation potentials would be identified and, wherever practical, Solar Envelopes would be constructed.

At first glance, the final neighbourhood plan would appear to be still more or less conventional, but it would represent the maximum energy efficient alternative which the market understands as a residential neighbourhood at the present time.

IN SEARCH OF A PARAGON

Any design strategy involves a two-directional approach. The procedure "from outside in" has been discussed in sufficient depth. The reverse direction still appears to be rather obscured. The neighbourhood design process as described makes sense only if two conditions are met:

- we know, understand and can describe the outside environment;

- we know, understand and can describe the internal logic, the spatial and social dimensions of an ideal neighbourhood.

The problem lies in the fact that we do not have such an ideal concept of a neighbourhood. The present prototype appears to be hopelessly obsolete and yet there is no consensus as to what constitutes an ideal.

To avoid this deadlock, we propose to establish Maturation Zones as escape hatches to potential futures. The idea is based on the fact that settlements in stable conditions are maturing anyway; hence there is an opportunity to steer this process. A doubt might arise, however, as to whether the Maturation Zone concept alone is a sophisticated enough instrument to accommodate all transition pressures under all circumstances.

Let us take a second look.

For the purpose of this report, growth is understood as increasing mass by constructing new buildings and by extending the existing ones. Maturation is a process by which the variety of human activities are progressively increasing. In the planning practice, this variety would fall into the category of mixed land use. We can also say that maturation is a trend which gradually moves a neighbourhood away from the original evolutionary infantile bedroom ghetto concept.

The potential for growth and maturation can be easily identified from the Land Form Description chart (page 27). If Maturation Zones are determined by the outside environment such as land form, two problems might easily result:

i) What is to be done if the proposed Maturation Zone is utterly in conflict with the inner logic of the present layout of the neighbourhood? What if this zone, for example, is running through, and absorbing, most of the neighbourhood open space?

ii) What is to be done in the absence of any definite message from the Land Form Description? Where would we provide for future growth and maturation in case a whole neighbourhood is almost flat or almost uniformly sloped?

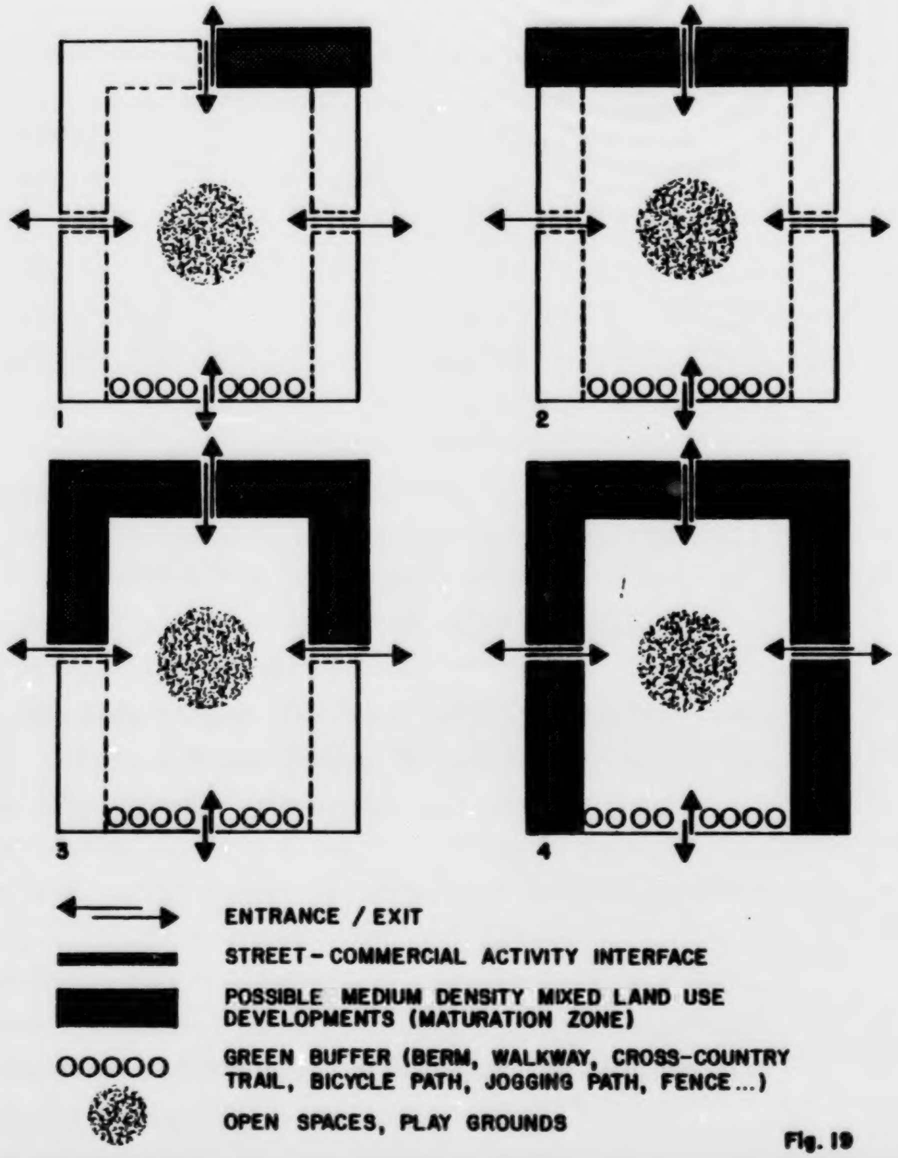
Inevitably, to answer these questions, we are forced to envisage some sort of future, even at the risk that such a future might never take place.

As a design exercise, and for discussion purposes only, two hypothetical spatial scenarios are proposed.

1. The Bear Hug (FIG. 19)

The completely developed "Bear Hug" neighbourhood concept would consist of medium density, mixed land use, linear development along the north, east, and west arterial roads. It forms a sort of upside down "U" shape open to the south.

Its physical adjacency to arterial roads obviously encourages many associations of activities. Through the process of maturation, the three intensively


1
2
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ENTRANCE / EXIT
STREET - COMMERCIAL ACTIVITY INTERFACE
POSSIBLE MEDIUM DENSITY MIXED LAND USE DEVELOPMENTS (MATURATION ZONE)
GREEN BUFFER (BERM, WALKWAY, CROSS-COUNTRY TRAIL, BICYCLE PATH, JOGGING PATH, FENCE...)
OPEN SPACES, PLAY GROUNDS

Fig. 19

developed sides of the neighbourhood would consist of mixed land use including commercial and possibly even some selected industrial uses.

Inward, towards the centre of the neighbourhood, the mass of the development would be scaled down to accommodate the need for lower density residential accommodation. The very central part of the neighbourhood would be developed in a conventional manner: schools, parks, open spaces and plenty of detached, single family houses.

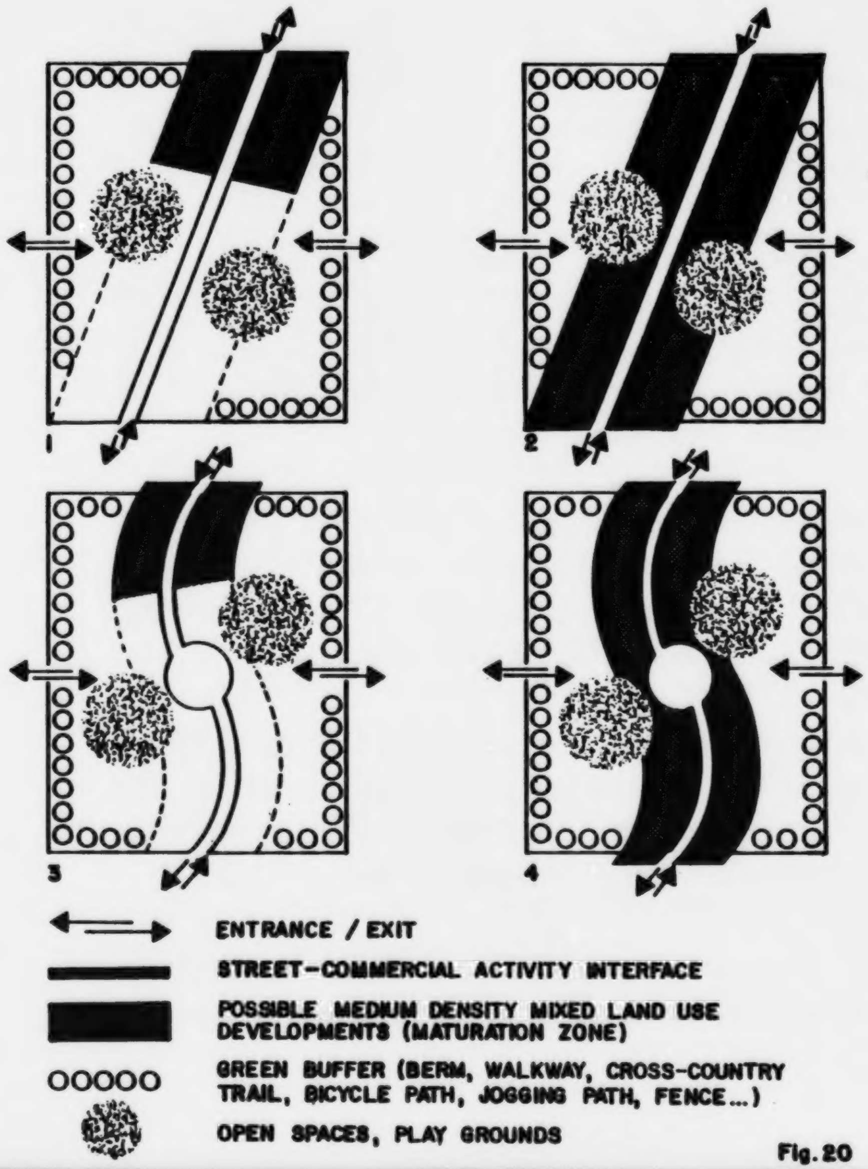
Number four is a scheme of a complete "Bear Hug" concept. Numbers one, two and three indicate evolutionary stages. This particular scheme could be superimposed over practically any conventional neighbourhood layout. Maturation Zones are located on the periphery, and thus the centre of the neighbourhood would remain unaffected by the transition. Furthermore, the "Bear Hug" concept naturally accommodates developmental pressures induced by the transportation artery.

2. The Broadway (FIG. 20)

The "Broadway" concept is based on a different premise. Here the neighbourhood is turning its back on the arterial network. A green buffer wall surrounds all four sides and contact with the outside world is channelled exclusively via the four gates. The centre is intensively developed along the north/south axis. The peak of development is in the centre and it is scaled down towards the periphery. The north/south axis - the Broadway - is a wide, well designed and landscaped urban street with adjacent commercial establishments. The Broadway would be designed to inhibit extraneous traffic and entice neighbourhood circulation. A mini-square or at least a rondel would enrich the local flavour. Numbers two and four represent a completed scheme; numbers one and three, evolutionary stages.

In essence, a "Broadway" for a neighbourhood plays the same role as the spine does for a vertebrate.

These two mutually exclusive neighbourhood concepts should help to initiate a meaningful discussion on developmental neighbourhood options.


1
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ENTRANCE / EXIT
STREET-COMMERCIAL ACTIVITY INTERFACE
POSSIBLE MEDIUM DENSITY MIXED LAND USE DEVELOPMENTS (MATURATION ZONE)
GREEN BUFFER (BERM, WALKWAY, CROSS-COUNTRY TRAIL, BICYCLE PATH, JOGGING PATH, FENCE...)
OPEN SPACES, PLAY GROUNDS

Fig.20

The "Bear Hug" concept should be relatively easier to adopt as it is possible to superimpose it over all existing concepts without driving developers and authorities out of their skins.

On the other hand, the "Broadway" concept is more demanding. It departs significantly from current practices. The implementation of this concept would require extensive understanding and the cooperation of all the parties involved.

Local environmental conditions determine the shape, size and survival strategies of living systems. Human-made ecological systems (buildings, neighbourhoods, settlements) are subject to the same natural laws.

The "Broadway" and "Bear Hug" neighbourhood concepts are only suggestions on how to carve new niches in the natural environment. They are just two ideas submitted for discussion, for futher development and refinement.

Both the ideas presented here are in a prenatal stage. All we have attempted to do is to initiate the process.

HUMAN FACTORS, ET CETERA

For several decades, the invisible ties between the natural environment and our settlements were ignored and forgotten. They were not needed. Independent, free to choose whatever our hearts desired, we convinced ourselves that we were above all natural laws. It was magic which made that possible, the powerful and misleading magic of inexpensive energy.

As a result, the art of designing buildings and communities with respect to the natural surroundings was lost. In this report we have attempted to fill that gap and bring attention to the possible penalites for ignoring natural forces.

If our two-directional design approach is to be pursued further, a considerable amount of effort must be devoted to the inner logic and structure of a neighbourhood. The "Bear Hug" and the "Broadway" concepts were presented only to attract attention and to initiate additional research and study.

Neighbourhoods are time capsules. We are sending them into the future to house and to provide a comfortable living environment for other generations. However, even if we should refuse to consider the welfare of the unborn and try to gear everything to our needs and preferences, we must be cautious: the neighbourhoods built today will be our place to live in tomorrow, but tomorrow we will be different. Time is uncorruptible - we will become a "geritol" generation. Can we still live comfortably in the contemporary style of our neighbourhoods?

As the population age profile changes, the behaviour pattern will change as well. A dramatic decline in driving licences questions the continuation of our present shopping habits. We would probably design neighbourhoods and their amenities differently if we were convinced that the prevailing mode of shopping will be teleshopping and home delivery. Some argue that the friendly corner store is on the way back and thus we should provide for tricycle paths and all activity associations should be measured and expressed in walking time. What about parks, open spaces and recreation in general? Life will be different in the polydent future.

Yet there is another human factor to consider in developing new neighbourhood concepts.

According to Margaret Cavendish, the seventeenth century female poet, *"women live like bats or owls, labour like beasts and die like worms"*. This has probably never been totally true in the case of the North American woman, but the HUD office of Policy Development and Research observed in its recent report:

> *"She is more likely to work, either out of choice or necessity. She has fewer children and a longer life. She is more likely to live alone, both in her youth and in old age, and more likely to raise children alone. Yet the belief persists that she derives her whole sense of identity from her husband's job, her home and her children.*
>
> *Because of this misconception, women are burdened by a system that fosters separation of work and home, a lack of diversity in housing, inadequate child care, and lack of transportation."*

The message for neighbourhood planners is clear. Again, we are told that land use plans should integrate living, working and recreation; in other words, mixed land use with a diversity of adult activities.

Unfortunately, the sex-role revolution has not penetrated the neighbourhood planning process. The neighbourhood planner is locked into the colourful world of commercials. Females spend their day running around the house, excited about the performance of detergents. Thus all our present neighbourhoods are still "man" made.

The number of human factor considerations in the process of developing an ideal neighbourhood prototype is countless, and it deserves special study. However, one more is included here.

The traditional design philosophies were derived from systems of visual order. The ultimate order is perfect; nothing can be added, nothing can be subtracted. Such order is therefore ultimately beautiful and not subject to change over time.

But absolute categories-concepts are difficult to defend in times of turmoil. Artists and designers discarded the attributes of duration a long time ago. We have been admiring organic, dynamic, and even disposable architecture for some time.

Interestingly, despite the present evolutionary swing, a need for timeless values is continuously popping up. It manifests itself in the popularity of real and fake antiques and in pseudo-historical interior furniture and decoration. As we have observed, single family houses are often selected by appearance and not by the cost of maintenance and upgrading. The best seller in a subdivision is usually generously dressed in a gown of historical detailing; neither seller nor buyer understands its original purpose or meaning. History is manufactured and marketed like any other piece of merchandise.

Still, this fairly strong desire to be a part of the historical continuum, timelessness and in a sense immortality is a genuine human need and it requires the architect's and planner's response. Unfortunately, it would need more time than one generation to organize our minds in order to organize our settlements.

A curious question may still persist, however. If there is such a strong human desire or need, should we not at least try to come out with some answers on the neighbourhood planning level?

A partial answer could be the concept of "neighbourhood personification". This concept, if accepted, must of course be developed by the collective effort of all participants in the neighbourhood planning process. The following is a discussion to help initiate such a process.

The ecological approach to neighbourhood design is based on local environmental uniqueness. This leads to a unique layout and massing of buildings and structures, especially during the maturation period. We can take it one step further. A rule may be established that two neighbourhoods must not be the same. Each one must have distinguishable visual characteristics which are artistically emphasized.

Comprehension of spatial dimensions and orientation within the neighbourhood cen be assured by establishing another requirement related to the basic layout of streets. In essence, we would like to make it possible for a visitor to travel through the neighbourhood with only marginal help from street signs, without having to stop and rotate maps upside down, and without having to stop and shout questions at the occasional passer-by.

This requirement cannot be fulfilled without the introduction of some discipline and logic into the street pattern. Inevitably, a partial straightening would be needed. When discussing this idea with developers, the response was bluntly sincere: "We want curved streets because a prospective buyer must not be exposed to more than a few houses at a time. A whole street full of our houses is depressingly bare and it would scare a purchaser off."

One might suggest that this sounds as if it were taken from the cookbook of the Borgia family. If poison is administered in very small dosages, it is not harmful. Over time, you become immune to it and who knows, you may even begin to like it.

Those who not so long ago were trying to introduce the "maccaroni labyrinth" concept into neighbourhood design, against strong opposition from traffic departments, municipal engineers and of course developers, certainly had no idea how difficult it would be to replace it.

Planners never win in this world. They are always hit by their own boomerang.

The idea of "personification" can evolve into a broad system approach. It can encompass every aspect of neighbourhood design and planning.

Wherever the land form description permits, we may consider an ornamental street pattern. Possibly we might even borrow some older, historically verified, urban spatial concepts, such as boulevards, focus points, rondels, and intersections.

A properly executed urban design - third dimension planning - creates a unique neighbourhood and identity; it influences human spatial orientation, human behaviour and lifestyle in general.

Even in the very initial neighbourhood planning stages, when studying the local climatic conditions, the Ecochart, and the Land Slope and Orientation Analysis, we can arrive at profound decisions related to the "personality" of the neighbourhood.

The topography can be utilized more imaginatively. The bulldozer should turn into a sculptor's chisel. The highest point could be emphasized and could become the focal point of the neighbourhood. The lowest area, filled with water, would give us a pond or an intricate network of water channels.

In our future design guidelines, we may even stipulate that every neighbourhood must have a focal point; ideally it should be seen not only from any place within the neighbourhood but also from the outside, as a symbol and an identification mark. A focal point could be a church or some other prominant building constructed on a small hill, a bell tower, a clock tower, a tall sculpture, flag poles, etc.

Special attention should be given to neighbourhood parks and open spaces. Anyone who has had the opportunity to observe the activities in Centennial Park in Etobicoke during the entire year would agree that there is a case for imitation. This successful concept could easily be scaled down to a neighbourhood level. A small, fifty foot hill would tremendously enrich recreational potential and accommodate a wide range of summer and winter sports. A mini-Centennial Park for every neighbourhood is an idea worthy of consideration.

CONCLUDING REMARKS

The ecological approach to energy efficient neighbourhood planning is based on the premise that all living systems and human-made ecological systems such as shelters and communities are subject to natural forces. We are an integral part of the terrestrial as well as the celestial environment. The cumulative effect of the sun-earth relationship manifests itself in a cyclical annual and diurnal variation.

Our task is to provide reasonably comfortable shelters for human activities without paying excess environmental penalties. A re-introduction of the art of harnessing the accidental and periodical forces of nature is of particular importance during our present times of economic difficulties and uncertainties.

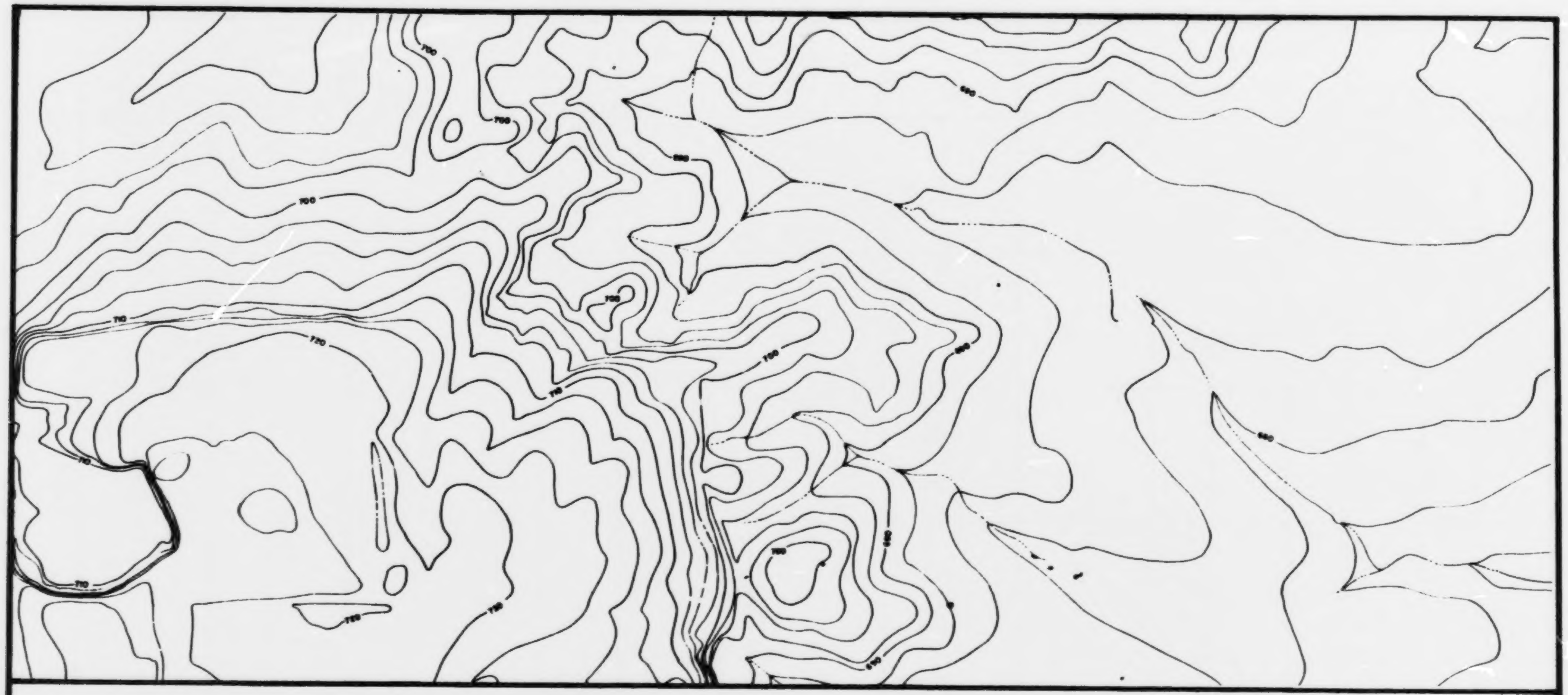
It should be stressed, however, that the arguments presented here must not be construed as anti-high technology statements. Quite the contrary: in our view, high technology appears to be the only remaining hope of solving our global problems without instituting tribal tyrannies and infant sacrifice rituals.

The point is that in adopting the ecological approach to planning our neighbourhoods and communities, we would relieve precious manufactured energy to be used in other, more important areas.

History is a merry-go-round. Chances are that in some distant future we might again be blessed with easy access to a seemingly inexhaustible source of energy. Let us hope that by that time we will be wise enough to develop our built environment more cautiously and responsibly, and we will avoid, if at all possible, the brutalities and pitfalls of the "cheap oil" era.

Part Three

Designer's Notebook


700
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730
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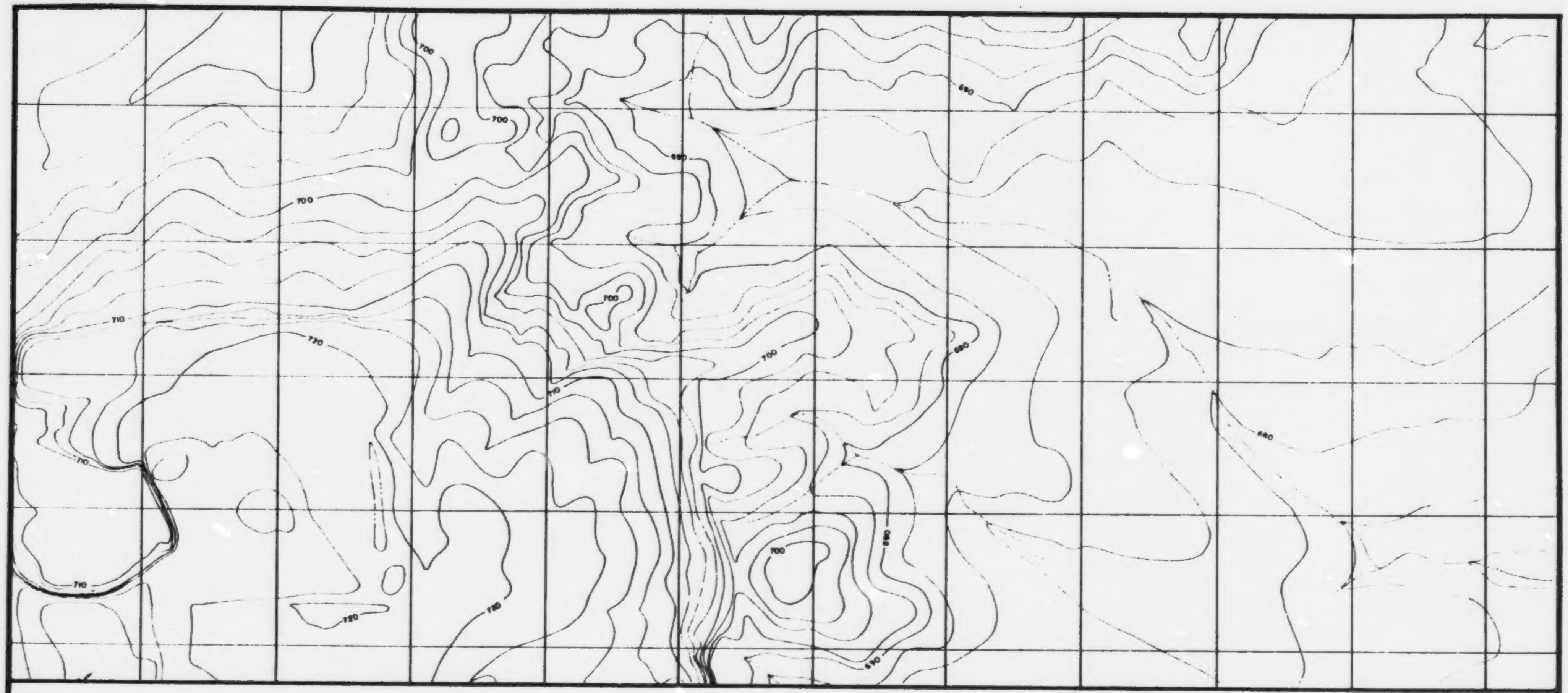
680
690
700
690
680

CONVENTIONAL CONTOUR MAP

SLOPE DESCRIPTIVE MATRIX

200 X 200 BASE GRID

SLOPE DESCRIPTIVE MATRIX


700
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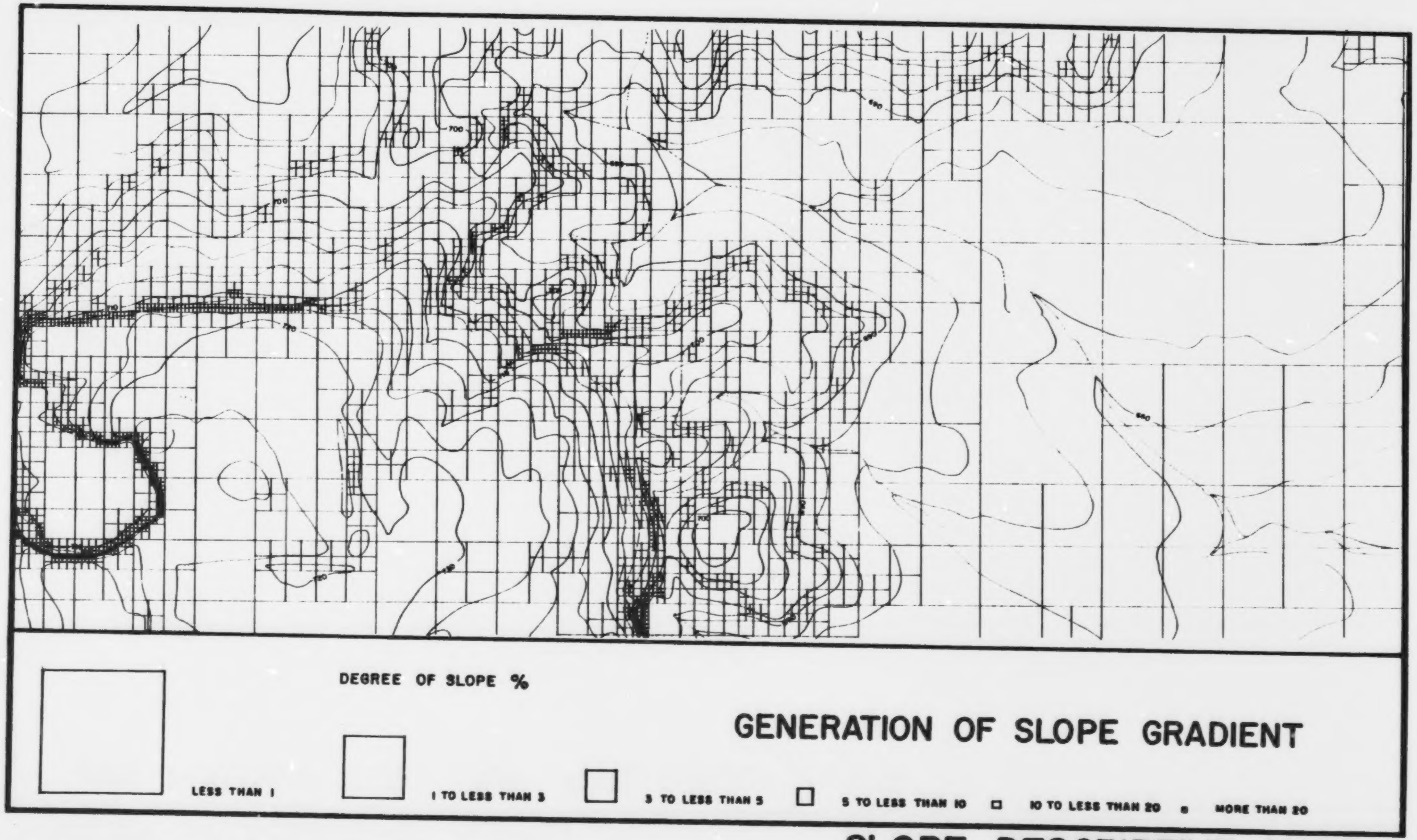
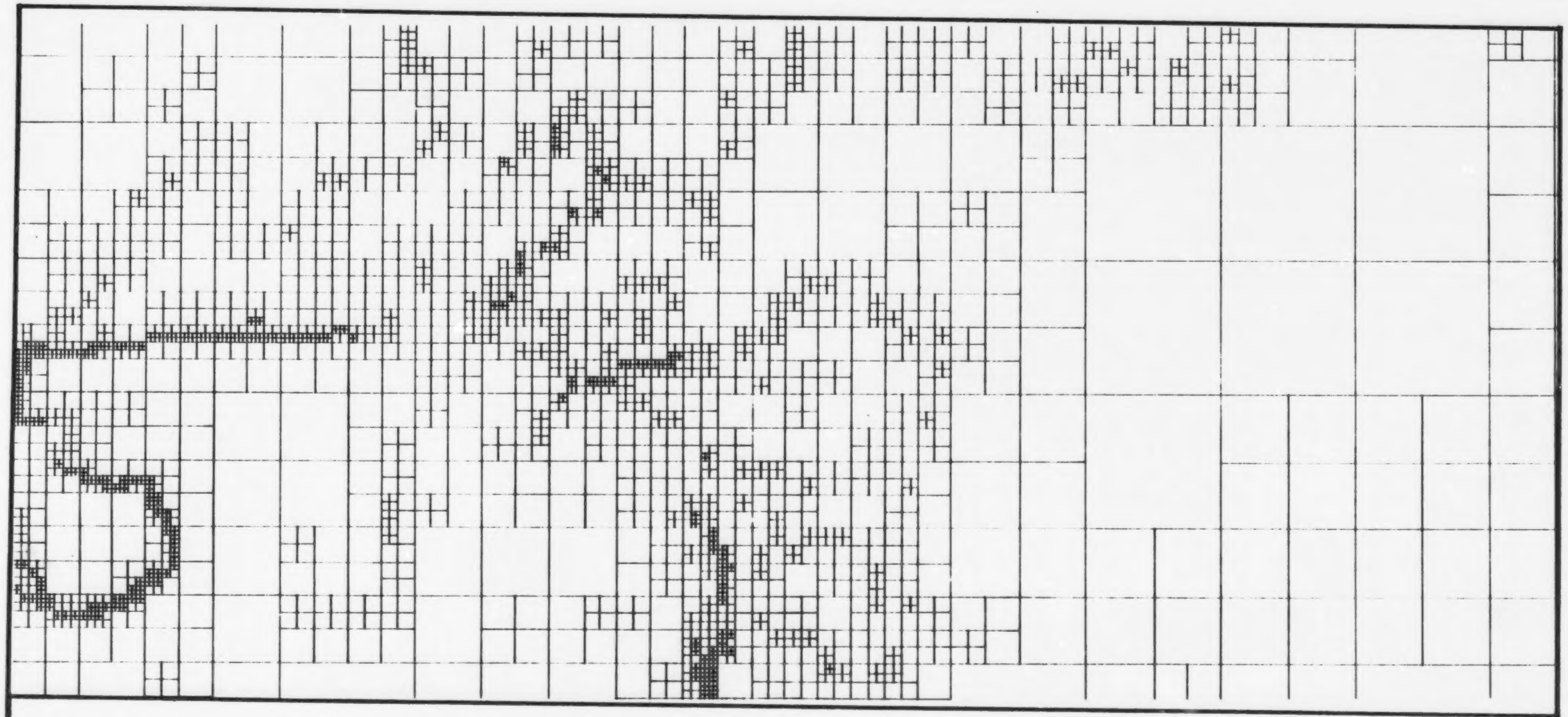
720
690

SUPERIMPOSED BASE GRID OVER CONTOUR MAP

SLOPE DESCRIPTIVE MATRIX

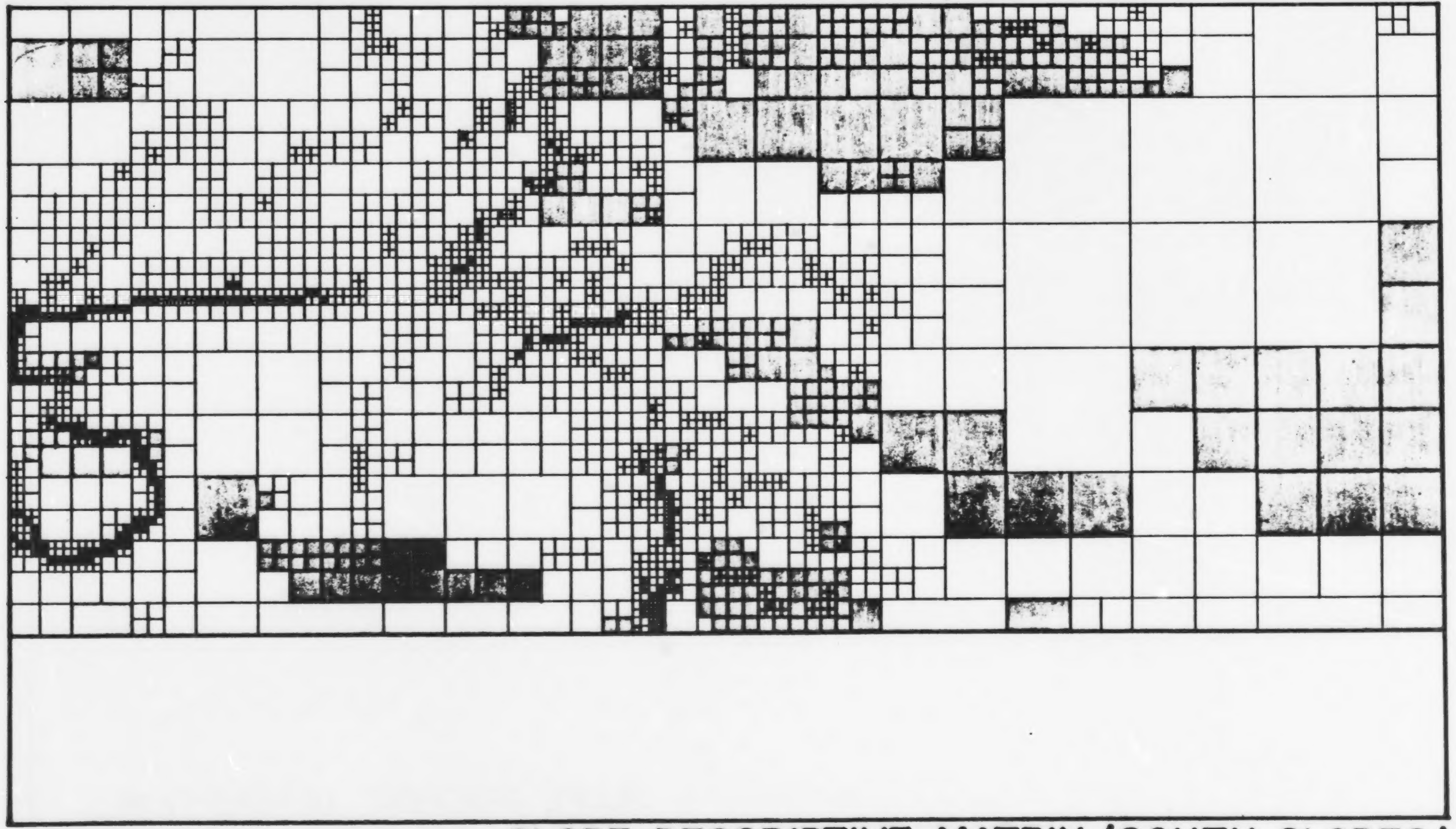

DEGREE OF SLOPE %
GENERATION OF SLOPE GRADIENT
LESS THAN 1
1 TO LESS THAN 3
3 TO LESS THAN 5
5 TO LESS THAN 10
10 TO LESS THAN 20
MORE THAN 20

SLOPE DESCRIPTIVE MATRIX

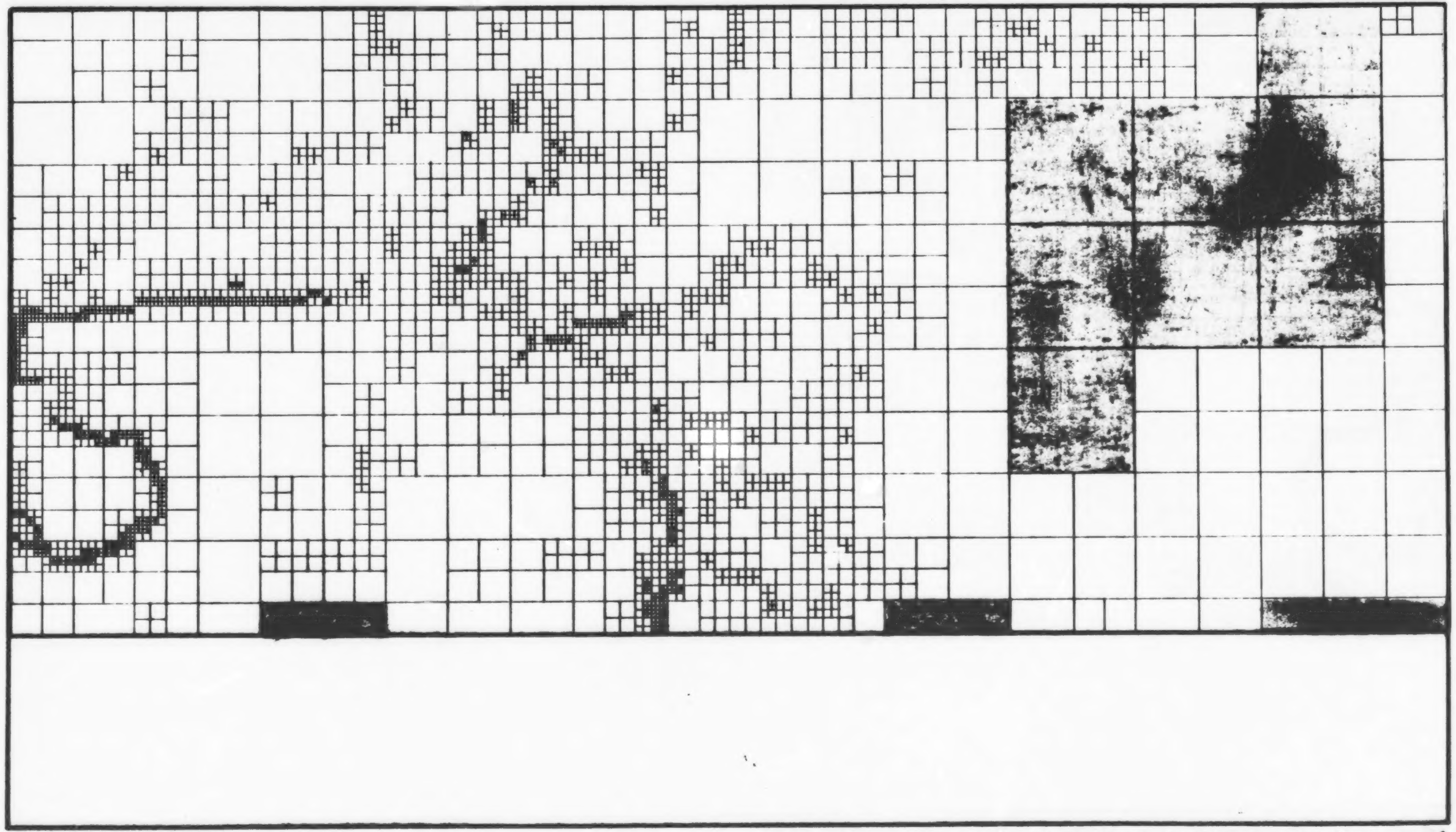


SLOPE GRADIENT DESCRIPTION

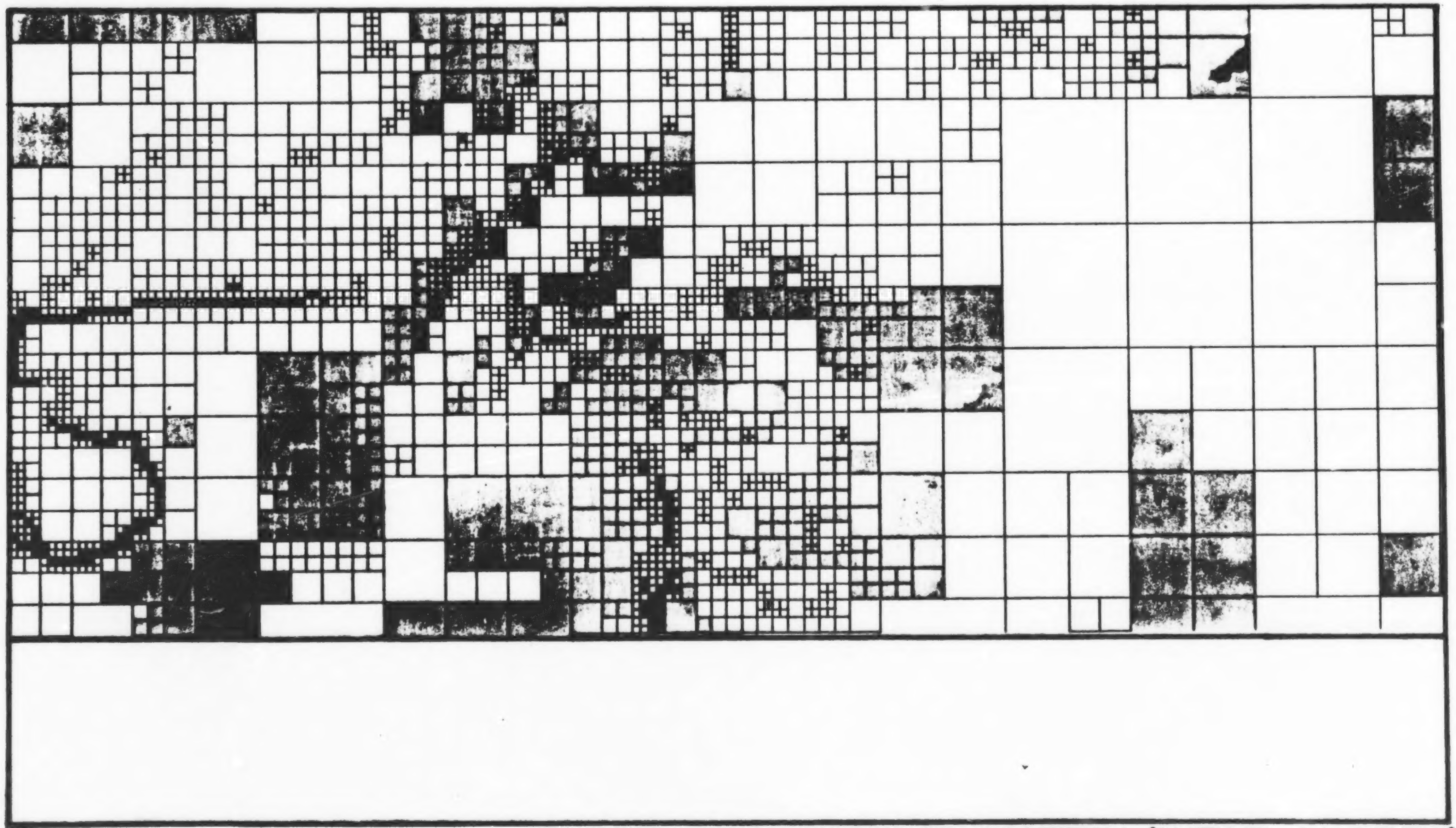
SLOPE DESCRIPTIVE MATRIX



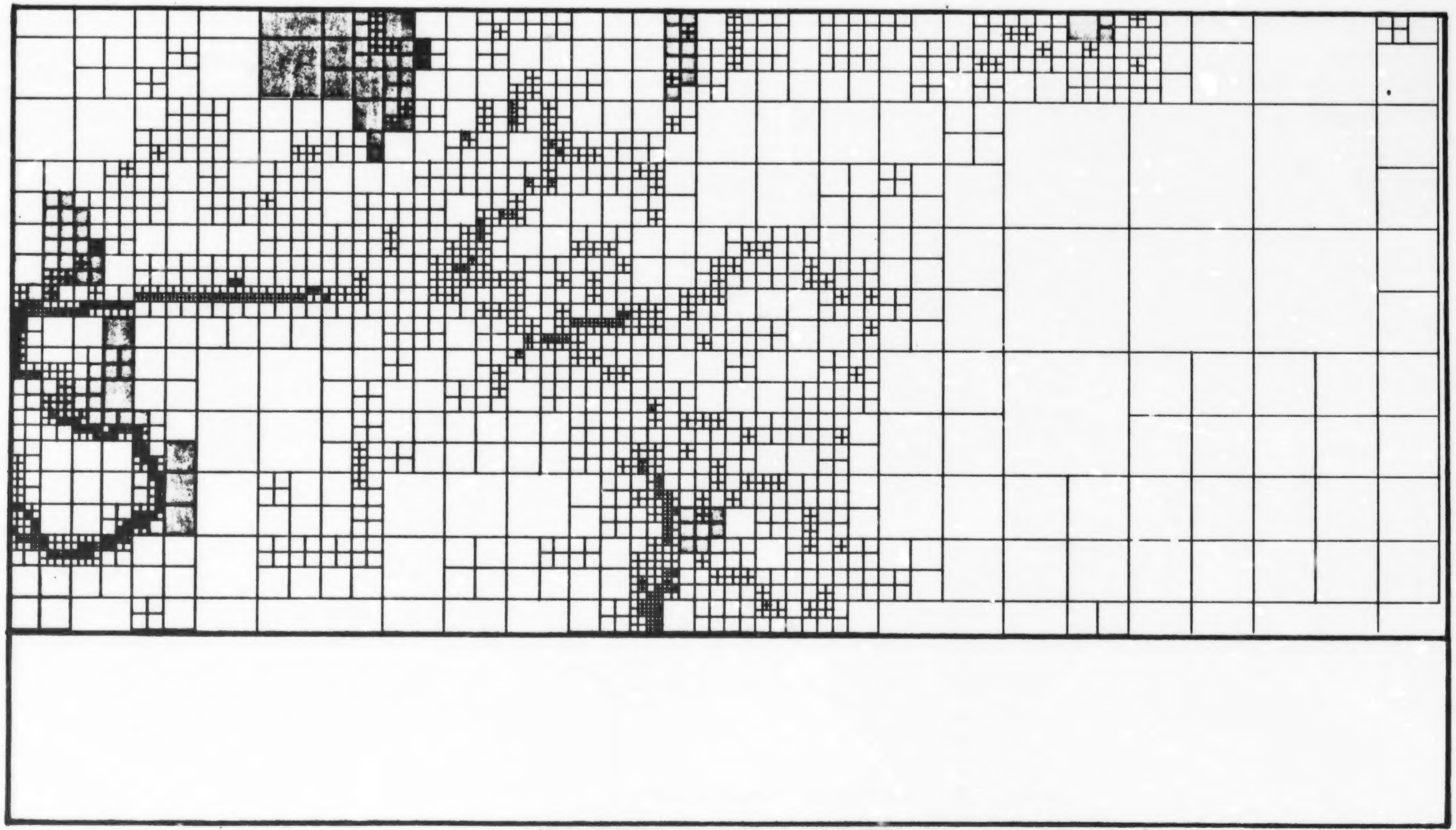
SLOPE DESCRIPTIVE MATRIX (SOUTH SLOPES)



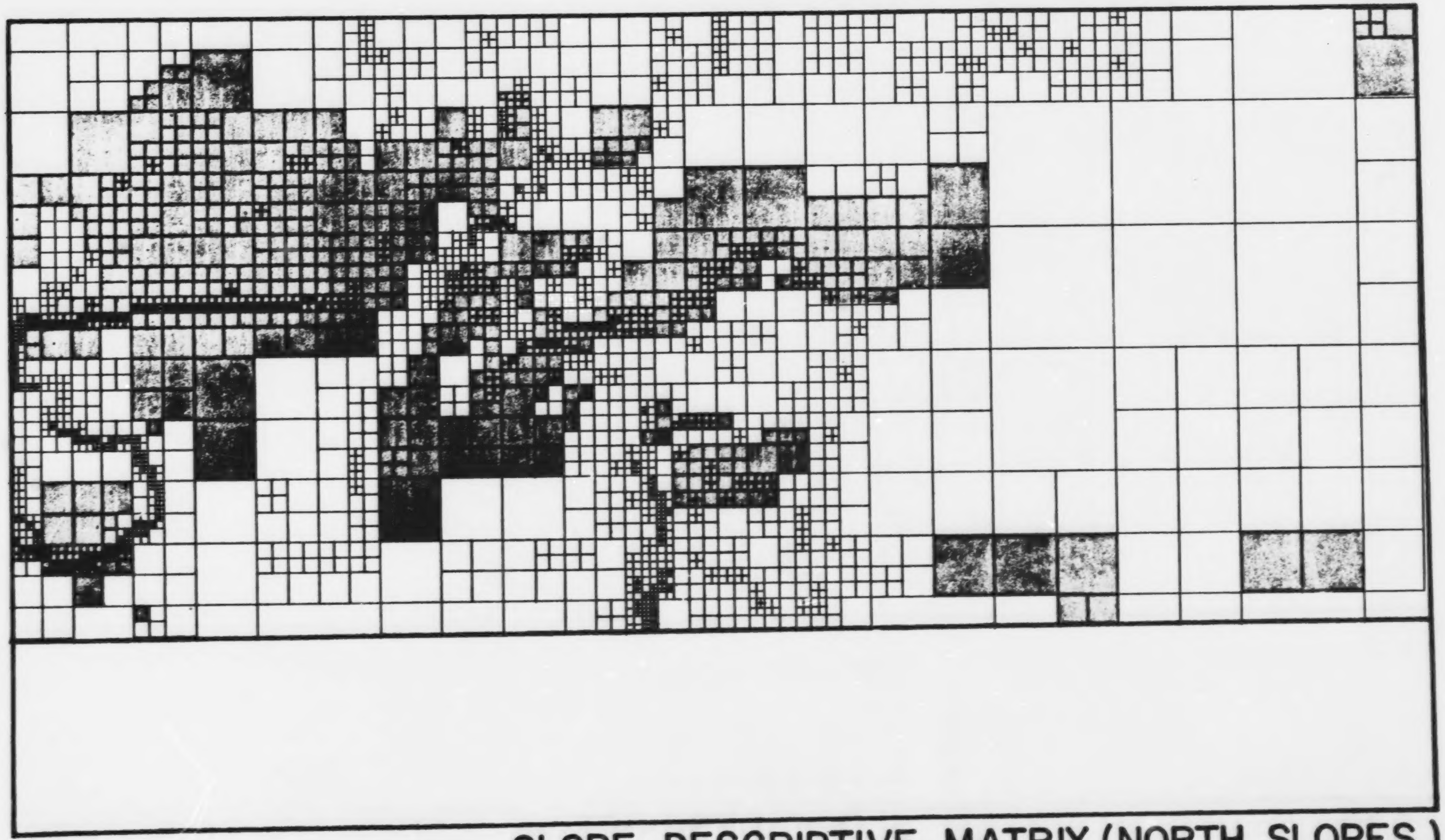
SLOPE DESCRIPTIVE MATRIX (FLAT)



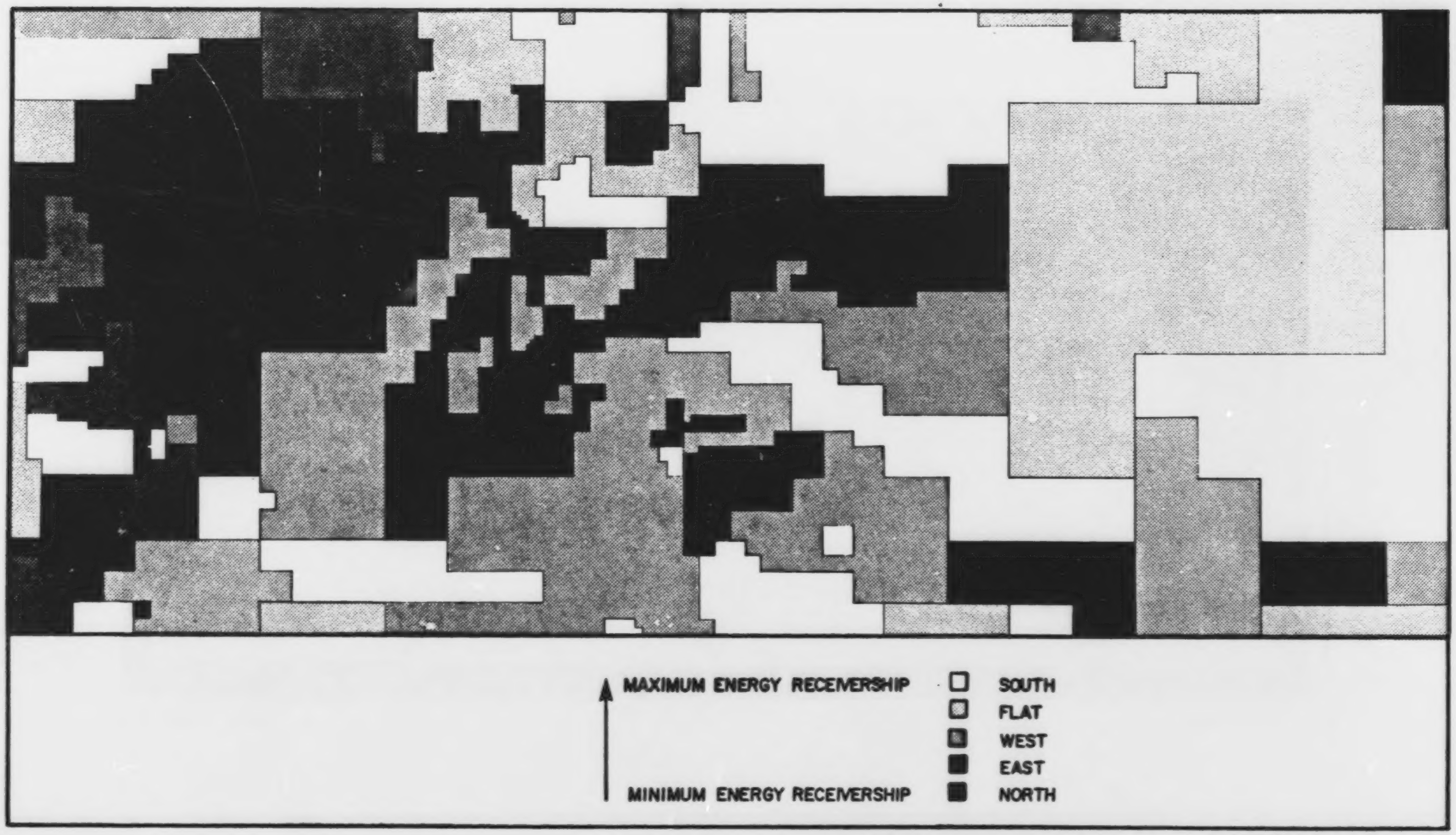
SLOPE DESCRIPTIVE MATRIX (WEST SLOPES)



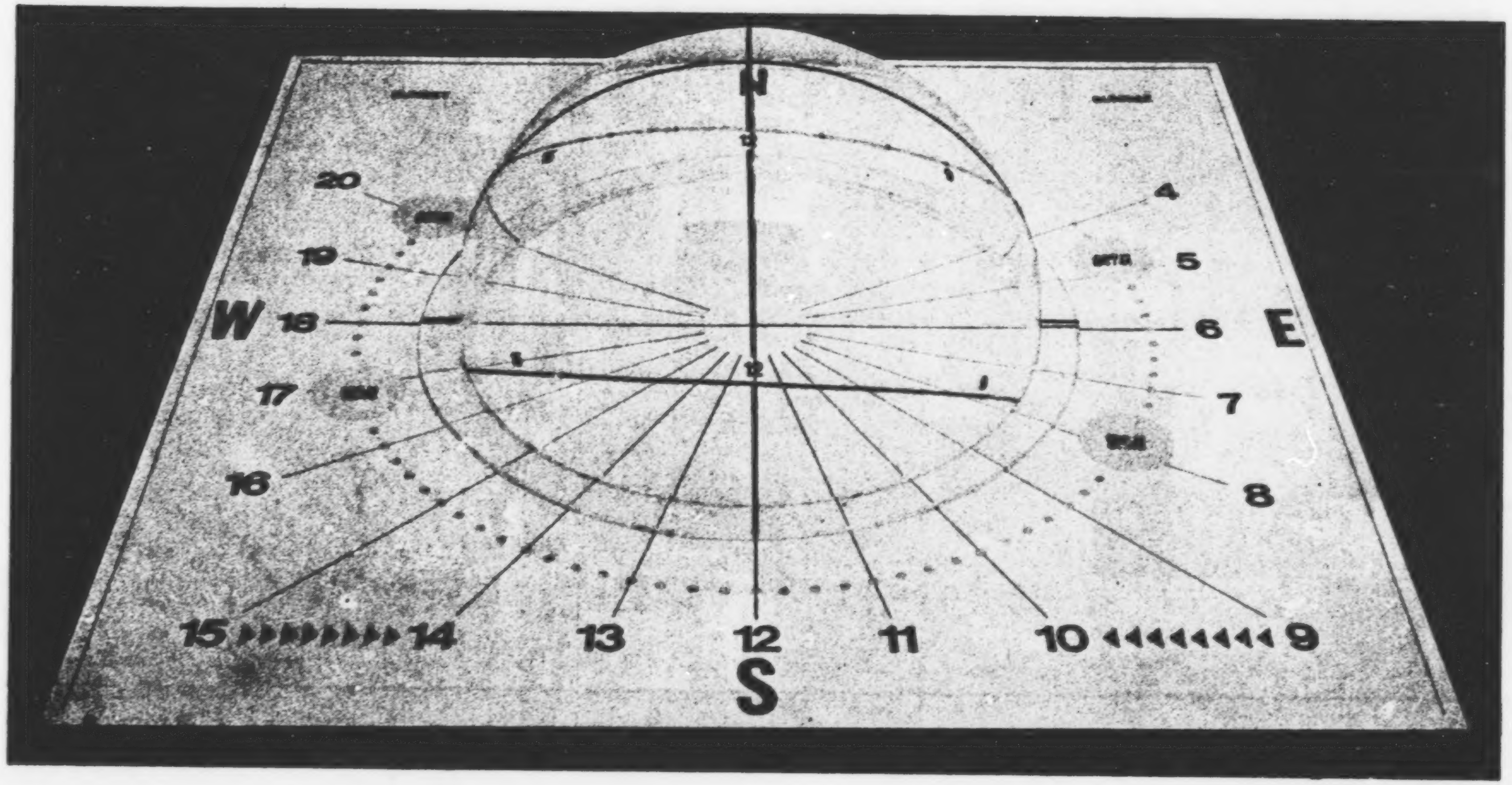
SLOPE DESCRIPTIVE MATRIX (EAST SLOPES)



SLOPE DESCRIPTIVE MATRIX (NORTH SLOPES)


MAXIMUM ENERGY RECEIVERSHIP
MINIMUM ENERGY RECEIVERSHIP
□ SOUTH
▨ FLAT
▨ WEST
■ EAST
■ NORTH

SLOPE ORIENTATION DESCRIPTION


N
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19
W 18
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13
12
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4
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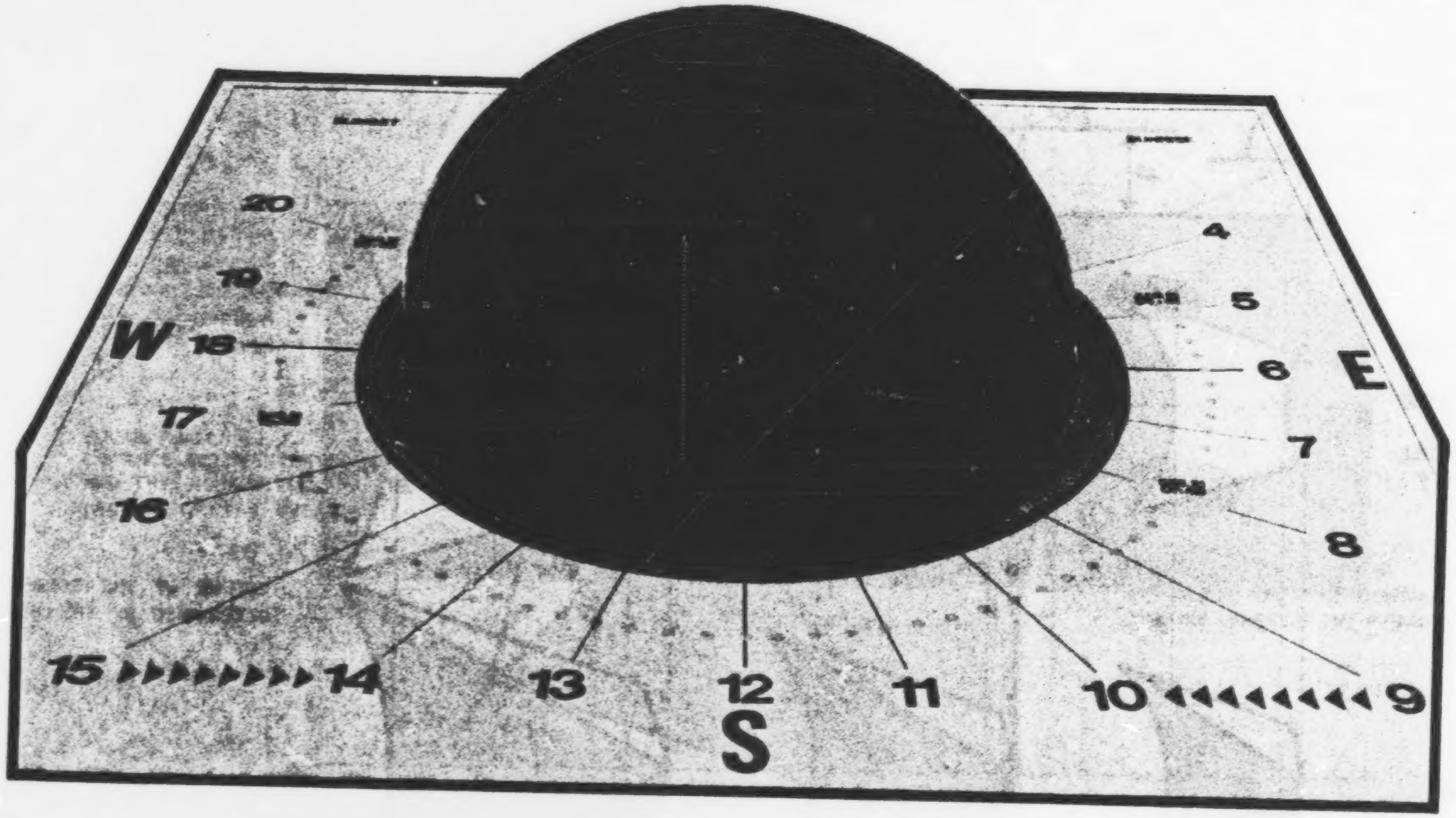
6 E
7
8
12

SEE PAGE..34

SKYDOME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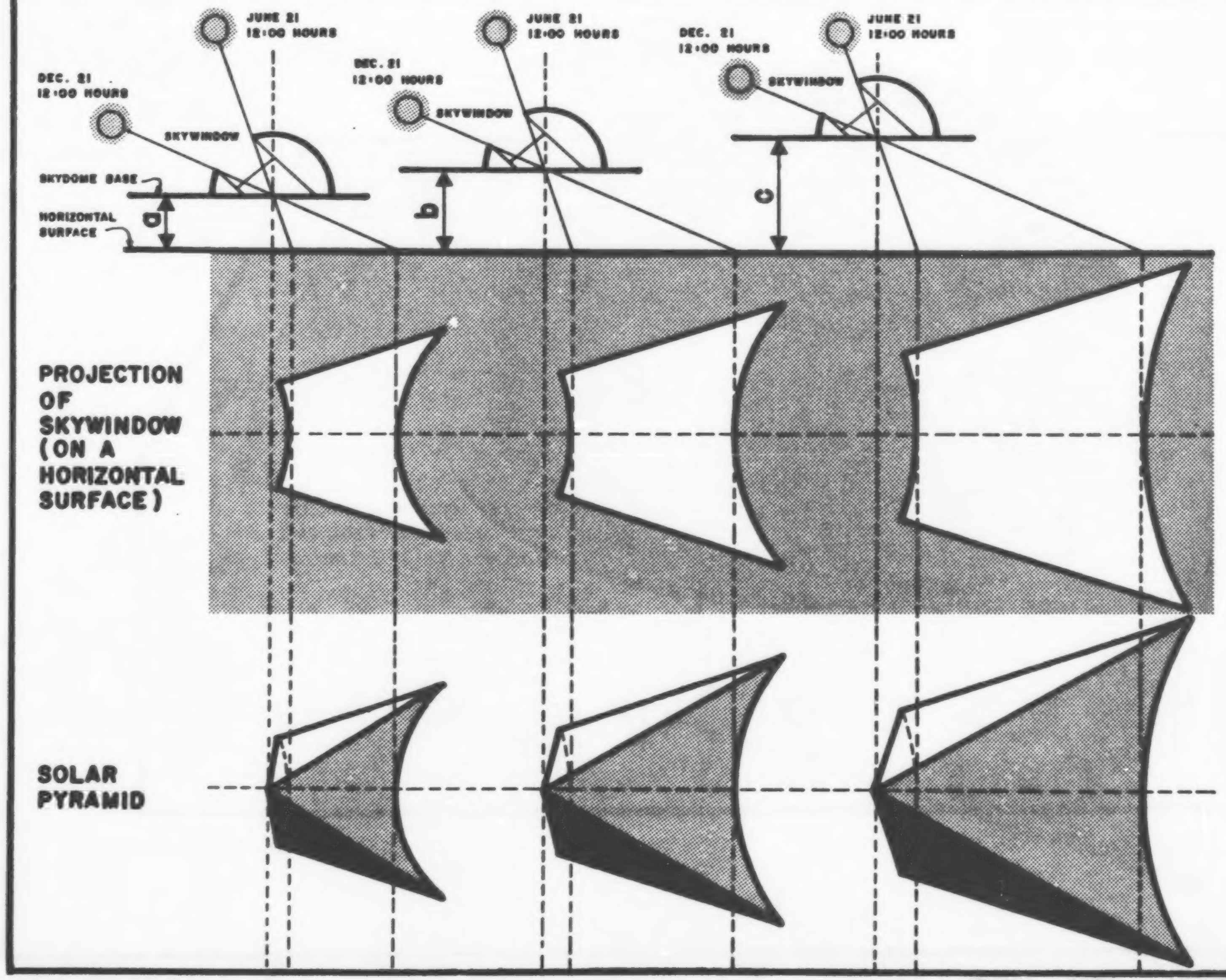
5
4

SEE PAGE.. 35

URBAN DOCUMENTATION CENTRE
RESEARCH UNIT FOR URBAN STUDIES
McMASTER UNIVERSITY
HAMILTON, ONTARIO

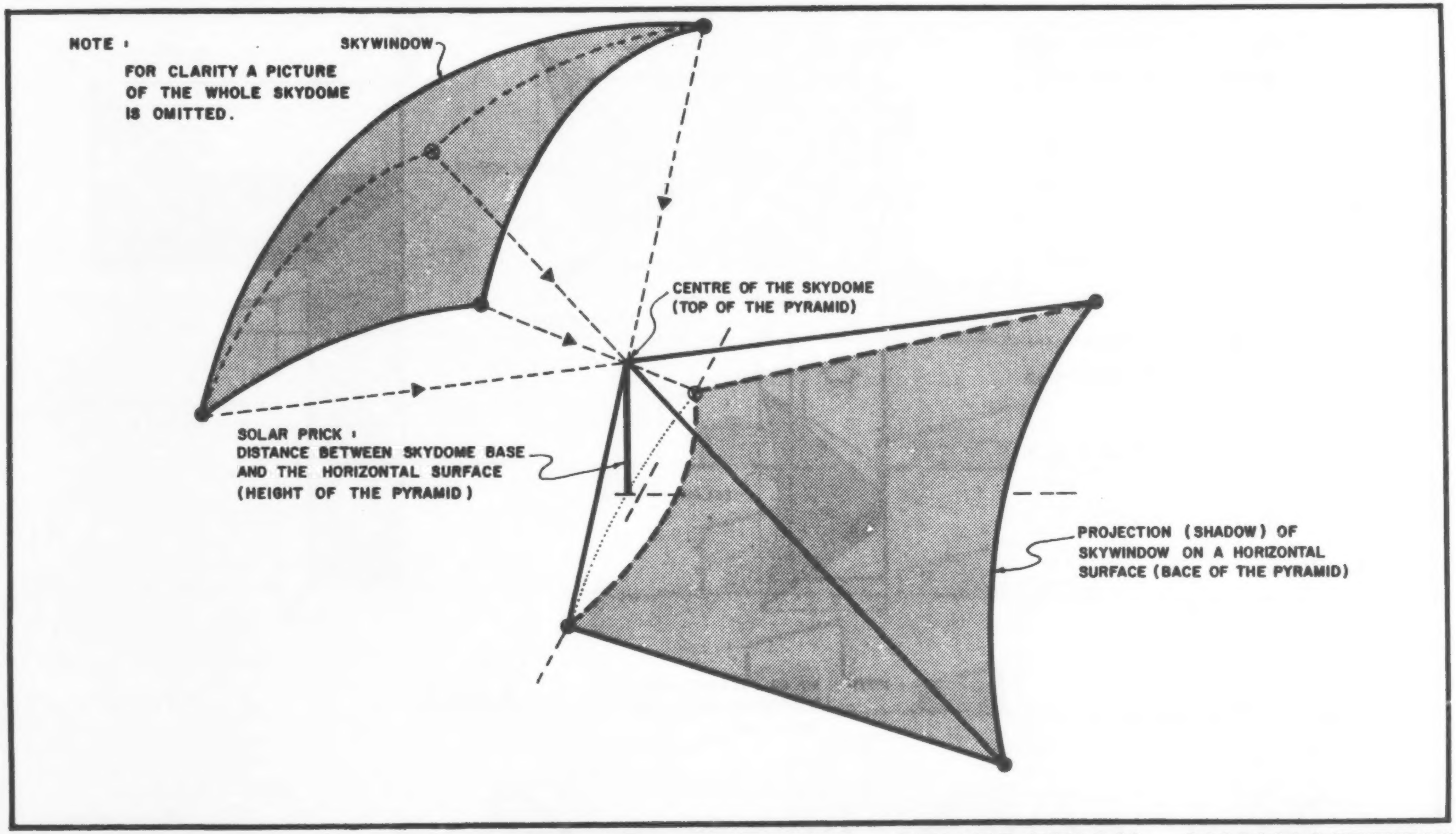
SKYWINDOW


JUNE 21
12:00 HOURS
DEC. 21
12:00 HOURS
SKYWINDOW
SKYDOME BASE
HORIZONTAL SURFACE
a
b
c
PROJECTION OF SKYWINDOW (ON A HORIZONTAL SURFACE)
SOLAR PYRAMID

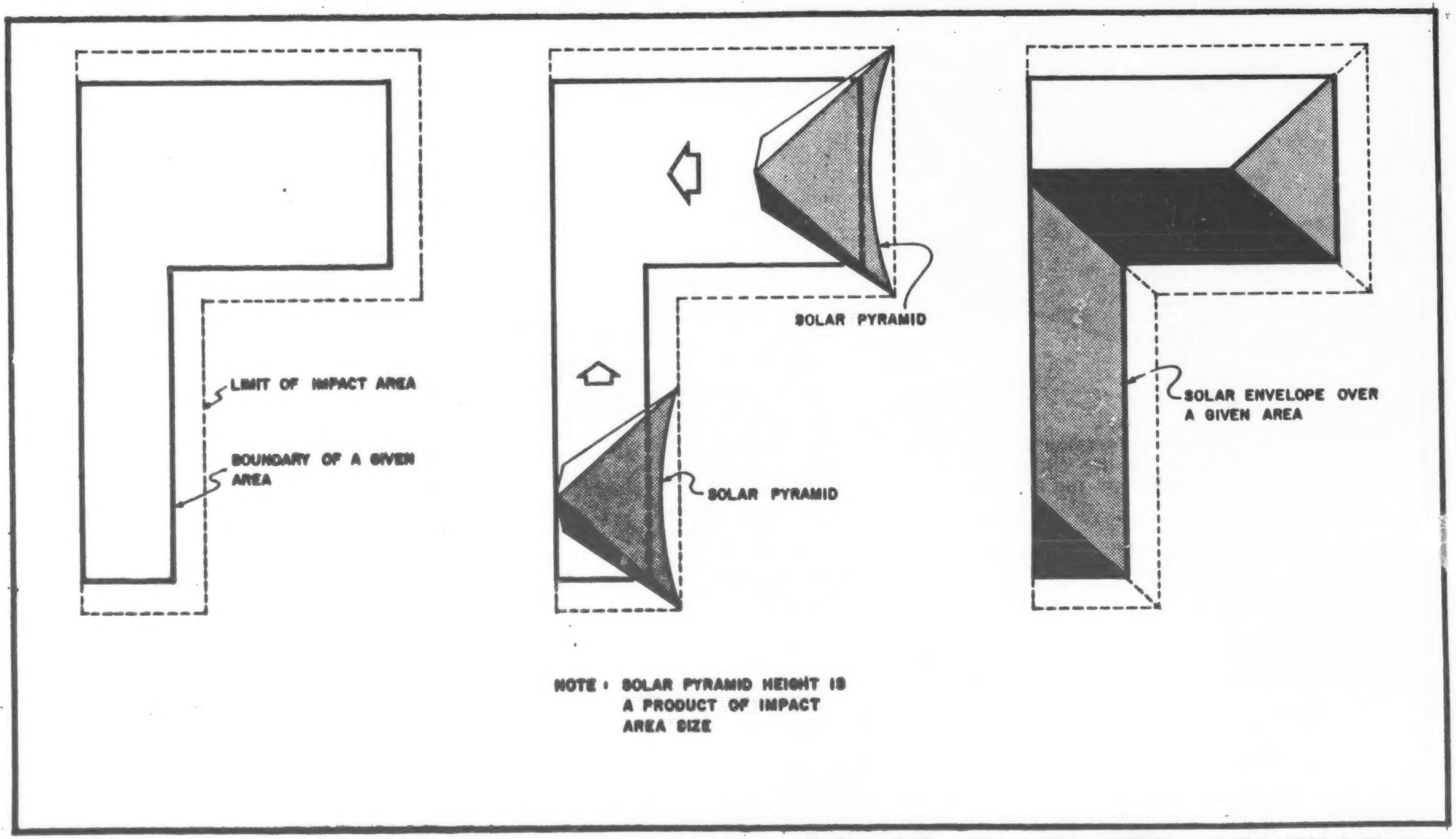
THE THREE PROJECTIONS OF THE SKY WINDOW ON A HORIZONTAL (FLAT) SURFACE IS EQUIVALENT TO A COMPOSITE (ANNUAL, DIURNAL, 09:00 - 15:00) SHADOW PATTERN OF POLES OF THREE DIFFERENT HEIGHTS.

VOLUME OF THE SOLAR PYRAMID IS DETERMINED BY THE HEIGHT "a", "b", AND "c".

SOLAR PYRAMID GENERATION

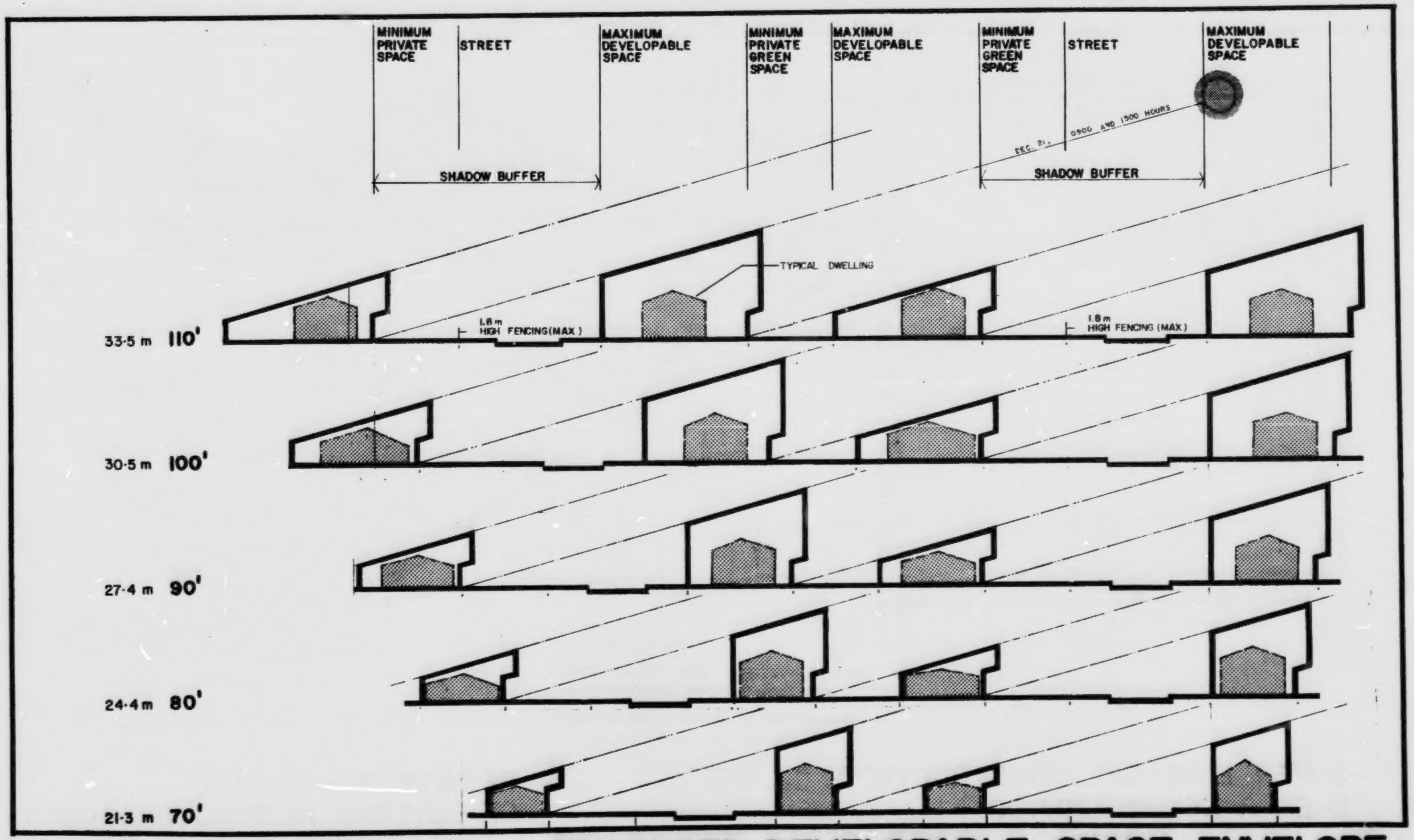

NOTE :
FOR CLARITY A PICTURE
OF THE WHOLE SKYDOME
IS OMITTED.
SKYWINDOW
CENTRE OF THE SKYDOME
(TOP OF THE PYRAMID)
SOLAR PRICK :
DISTANCE BETWEEN SKYDOME BASE
AND THE HORIZONTAL SURFACE
(HEIGHT OF THE PYRAMID)
PROJECTION (SHADOW) OF
SKYWINDOW ON A HORIZONTAL
SURFACE (BACE OF THE PYRAMID)

SOLAR PYRAMID GENERATION - AXONOMETRY

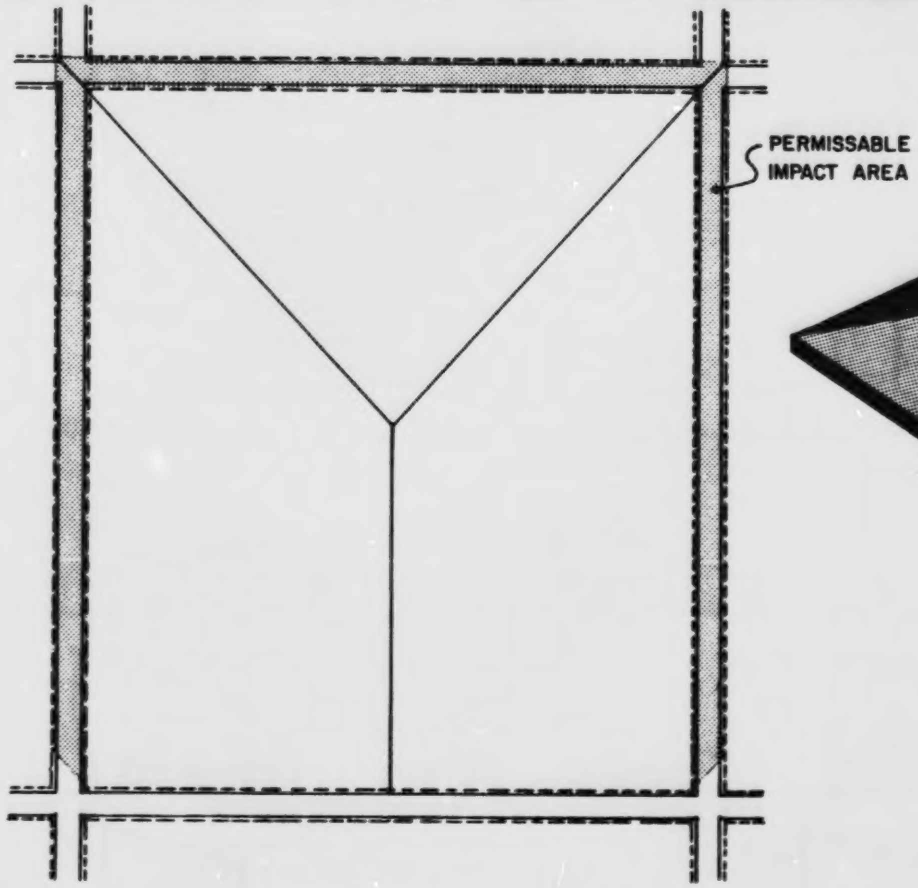

LIMIT OF IMPACT AREA
BOUNDARY OF A GIVEN AREA
SOLAR PYRAMID
SOLAR PYRAMID
SOLAR ENVELOPE OVER A GIVEN AREA

NOTE: SOLAR PYRAMID HEIGHT IS A PRODUCT OF IMPACT AREA SIZE

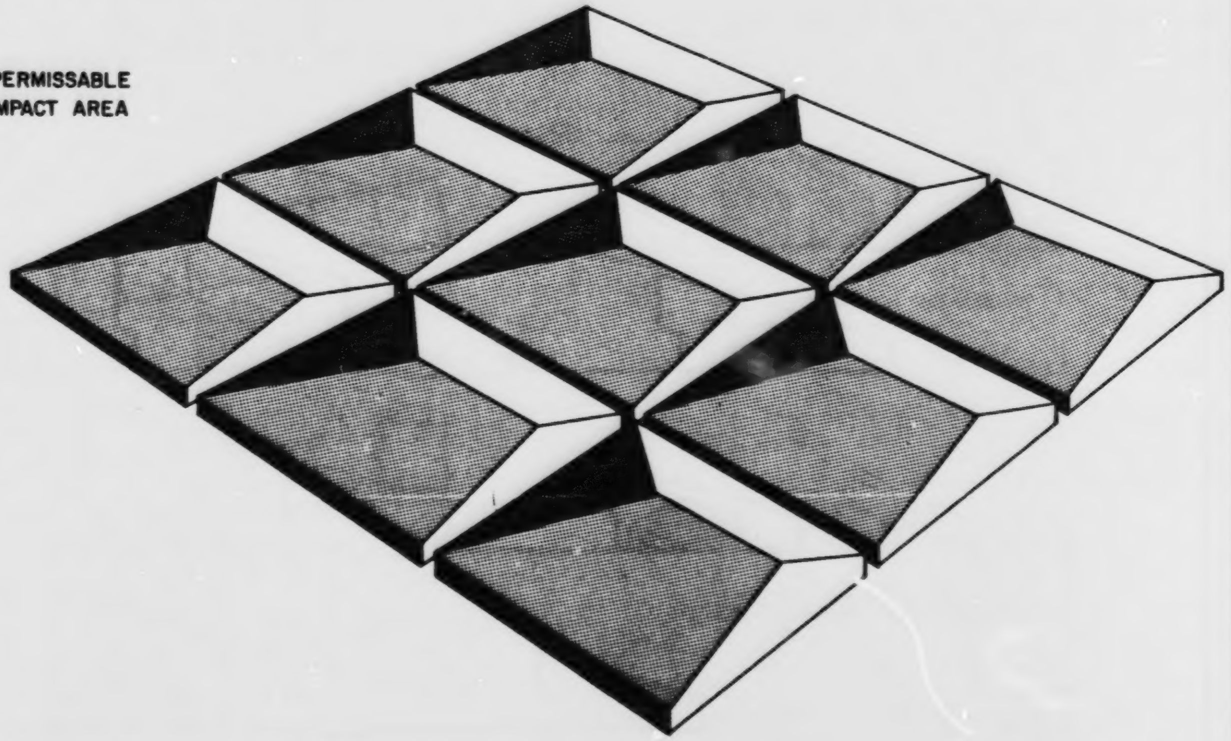
SOLAR ENVELOPE GENERATION


MINIMUM PRIVATE SPACE
STREET
MAXIMUM DEVELOPABLE SPACE
MINIMUM PRIVATE GREEN SPACE
MAXIMUM DEVELOPABLE SPACE
MINIMUM PRIVATE GREEN SPACE
STREET
MAXIMUM DEVELOPABLE SPACE
DEC. 21, 0900 AND 1500 HOURS
SHADOW BUFFER
SHADOW BUFFER
TYPICAL DWELLING
1.8 m HIGH FENCING (MAX)
1.8 m HIGH FENCING (MAX)
33·5 m 110'
30·5 m 100'
27·4 m 90'
24·4 m 80'
21·3 m 70'

EAST-WEST STREET - PROPOSED DEVELOPABLE SPACE: ENVELOPE

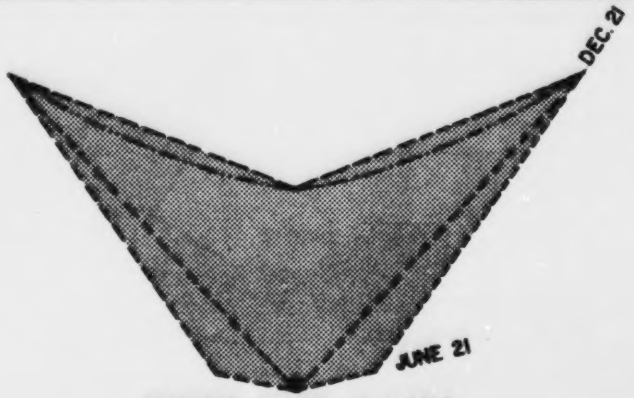

PERMISSABLE
IMPACT AREA

SUPER ENVELOPE CONSTRUCTED
OVER A NEIGHBOURHOOD

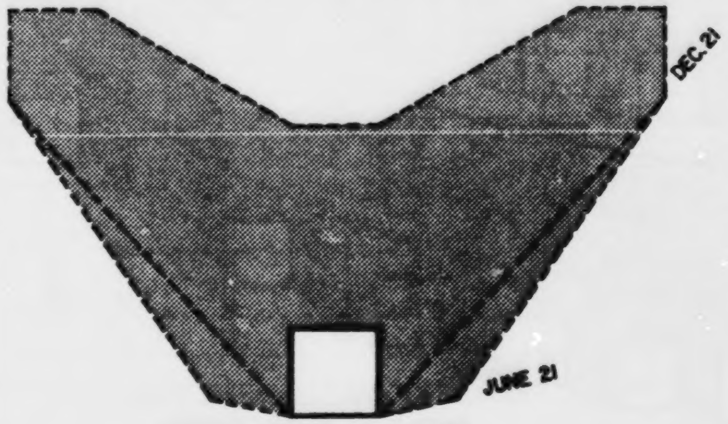


PERSPECTIVE SKETCH
OF SEVERAL NEIGHBOURHOODS

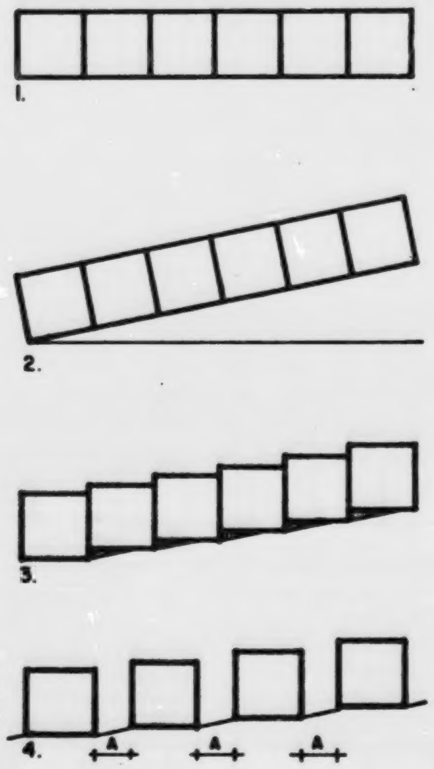
MAXIMUM DEVELOPABLE SPACE OUTLINE : SUPER ENVELOPE



COMPOSITE SHADOW OF A POLE BETWEEN JUNE AND DECEMBER

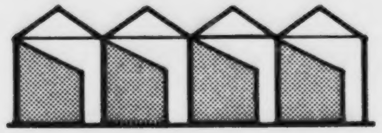


COMPOSITE SHADOW OF A HOUSE BETWEEN JUNE AND DECEMBER

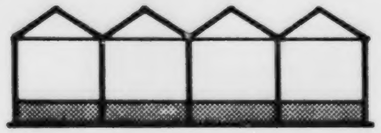


1. BEST ON EAST-WEST.
2. ONLY EAST-WEST ROW HOUSES WOULD TOLERATE SOME ± 13° DEVIATION FROM EAST-WEST AXIS.
3. VERTICAL OVERSHADOWING OF ONE HOUSE ON THE OTHER THROUGHOUT THE DAY.
4. FOR THE SOUTH FACADE NOT TO BE OVERSHADOWED THAN "A" IS THE LIMIT OF SPATIAL RELATIONSHIP.

SEE PAGE.. 36

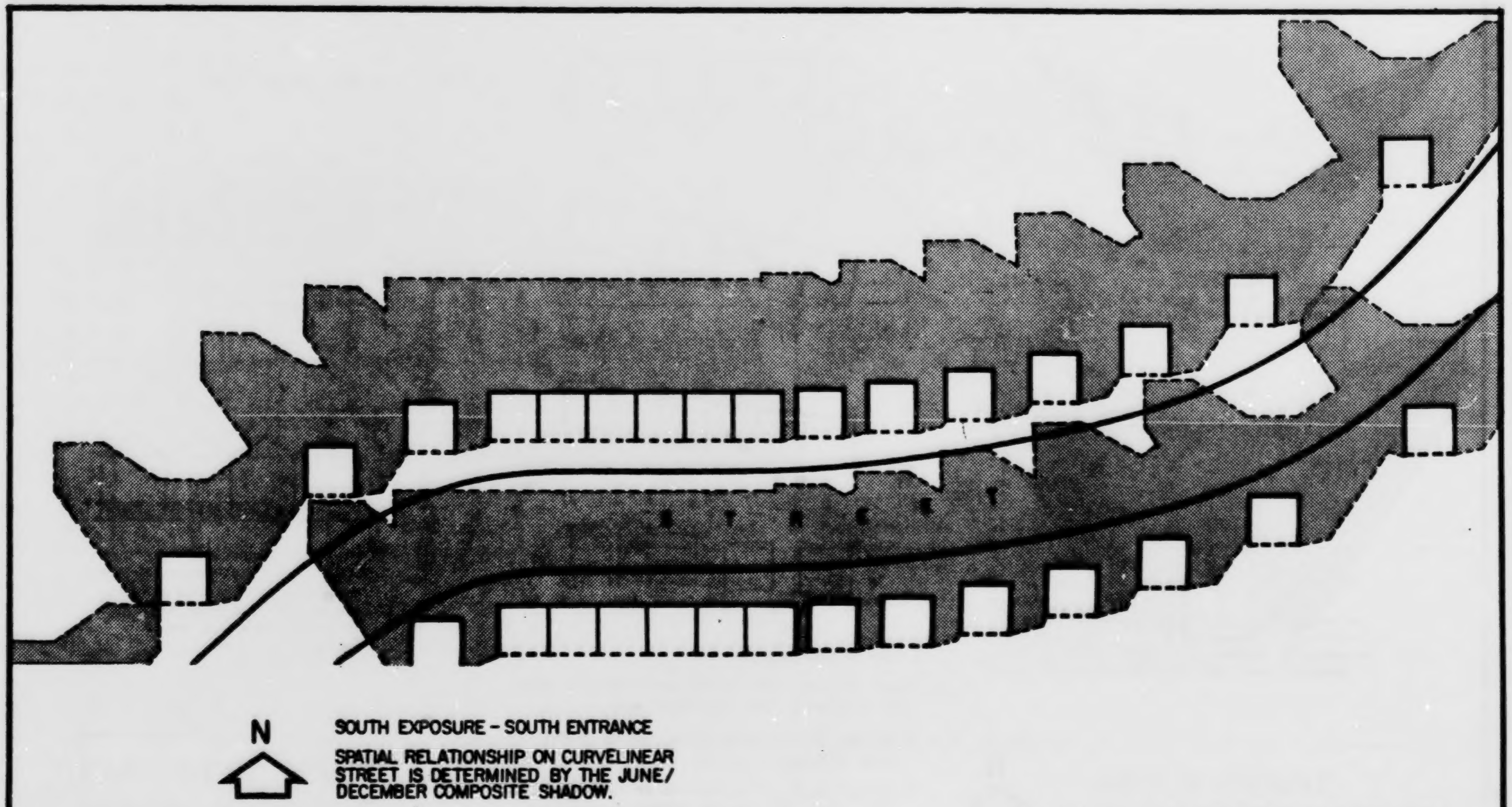


VERTICAL SHADOWING RELATES TO DIURNAL VARIATION.



IF SOME OVERSHADOWING MUST TAKE PLACE — ALLOW HORIZONTAL (SEASONAL) SHADOWING, AS IT IS LESS HARMFULL AND PERMITS THE UPPER PART OF THE HOUSE TO UTILIZE SOLAR ENERGY.

SHADOW CASTING ANALYSIS

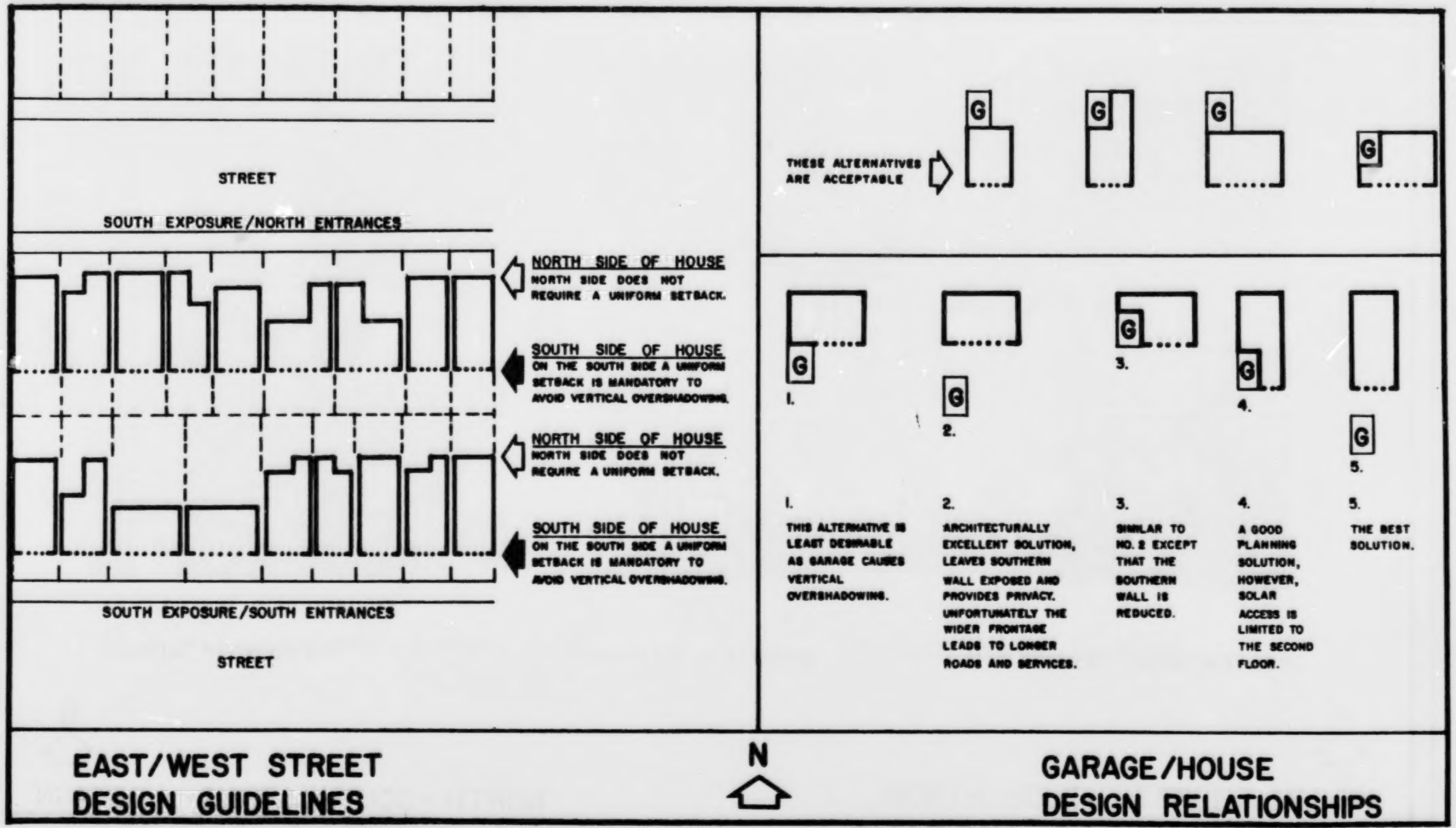


SOUTH EXPOSURE - SOUTH ENTRANCE

SPATIAL RELATIONSHIP ON CURVELINEAR STREET IS DETERMINED BY THE JUNE/ DECEMBER COMPOSITE SHADOW.

WINDING STREET DESIGN

SHADOW CASTING ANALYSIS


STREET
SOUTH EXPOSURE/NORTH ENTRANCES
SOUTH EXPOSURE/SOUTH ENTRANCES
STREET
THESE ALTERNATIVES ARE ACCEPTABLE
G
G
G
G
G
G
G
G
G
1.
2.
3.
4.
5.
N

NORTH SIDE OF HOUSE
NORTH SIDE DOES NOT REQUIRE A UNIFORM SETBACK.

SOUTH SIDE OF HOUSE
ON THE SOUTH SIDE A UNIFORM SETBACK IS MANDATORY TO AVOID VERTICAL OVERSHADOWING.

NORTH SIDE OF HOUSE
NORTH SIDE DOES NOT REQUIRE A UNIFORM SETBACK.

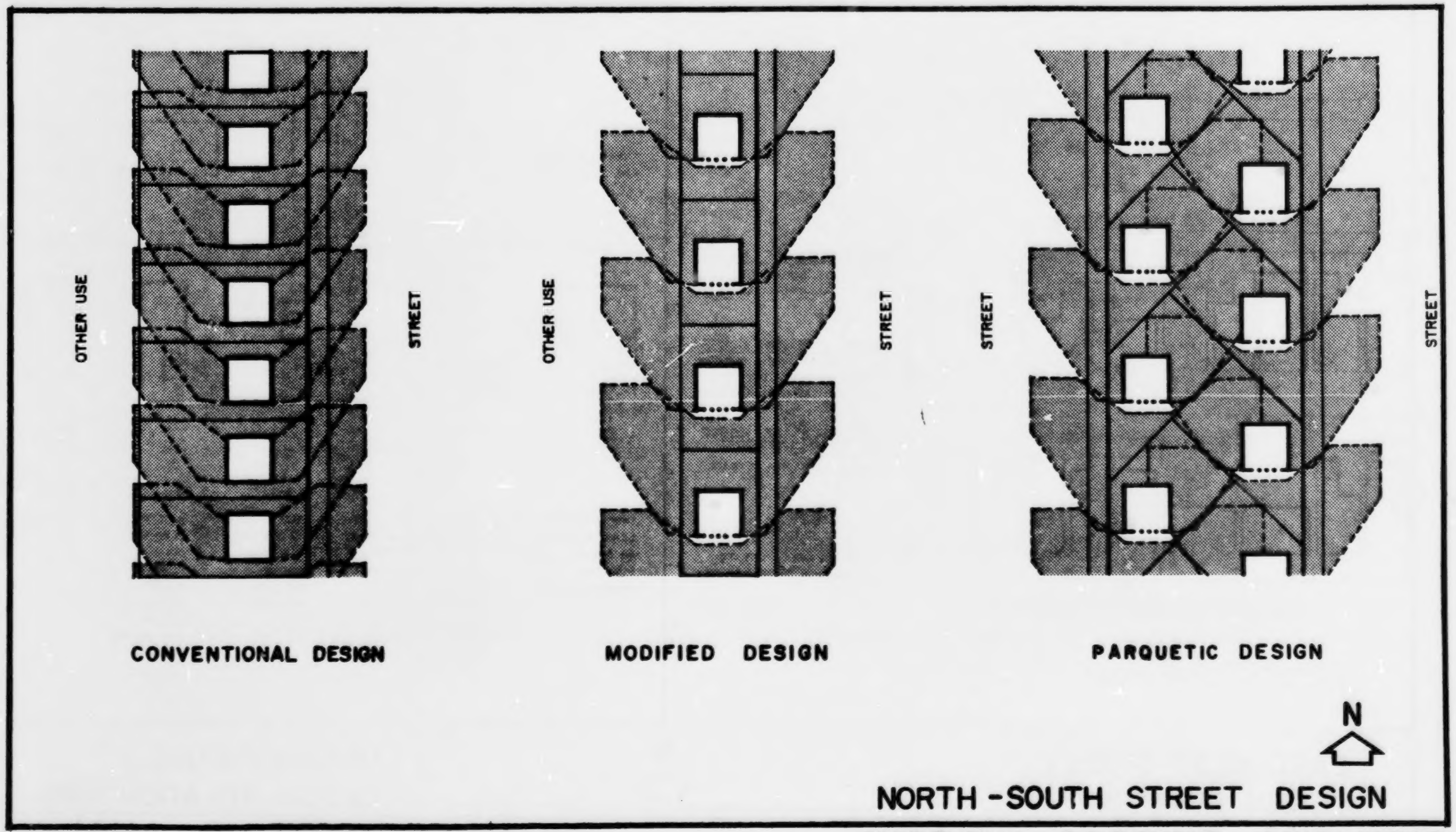
SOUTH SIDE OF HOUSE
ON THE SOUTH SIDE A UNIFORM SETBACK IS MANDATORY TO AVOID VERTICAL OVERSHADOWING.

1. THIS ALTERNATIVE IS LEAST DESIRABLE AS GARAGE CAUSES VERTICAL OVERSHADOWING.
2. ARCHITECTURALLY EXCELLENT SOLUTION, LEAVES SOUTHERN WALL EXPOSED AND PROVIDES PRIVACY. UNFORTUNATELY THE WIDER FRONTAGE LEADS TO LONGER ROADS AND SERVICES.
3. SIMILAR TO NO. 2 EXCEPT THAT THE SOUTHERN WALL IS REDUCED.
4. A GOOD PLANNING SOLUTION, HOWEVER, SOLAR ACCESS IS LIMITED TO THE SECOND FLOOR.
5. THE BEST SOLUTION.

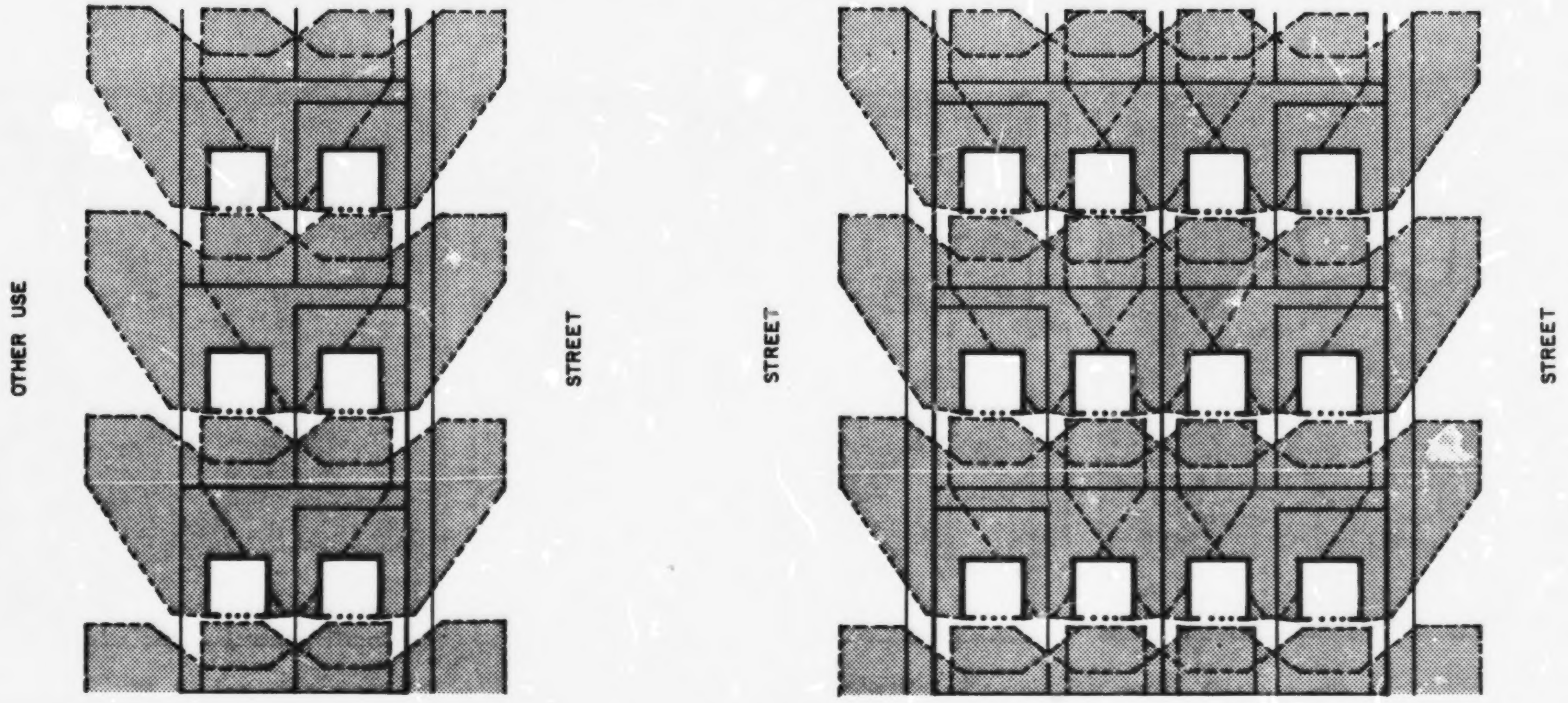
EAST/WEST STREET
DESIGN GUIDELINES

GARAGE/HOUSE
DESIGN RELATIONSHIPS

SHADOW CASTING ANALYSIS


OTHER USE
STREET
CONVENTIONAL DESIGN
OTHER USE
STREET
MODIFIED DESIGN
STREET
STREET
PARQUETIC DESIGN
N
NORTH - SOUTH STREET DESIGN

SHADOW CASTING ANALYSIS


OTHER USE
STREET
STREET
STREET

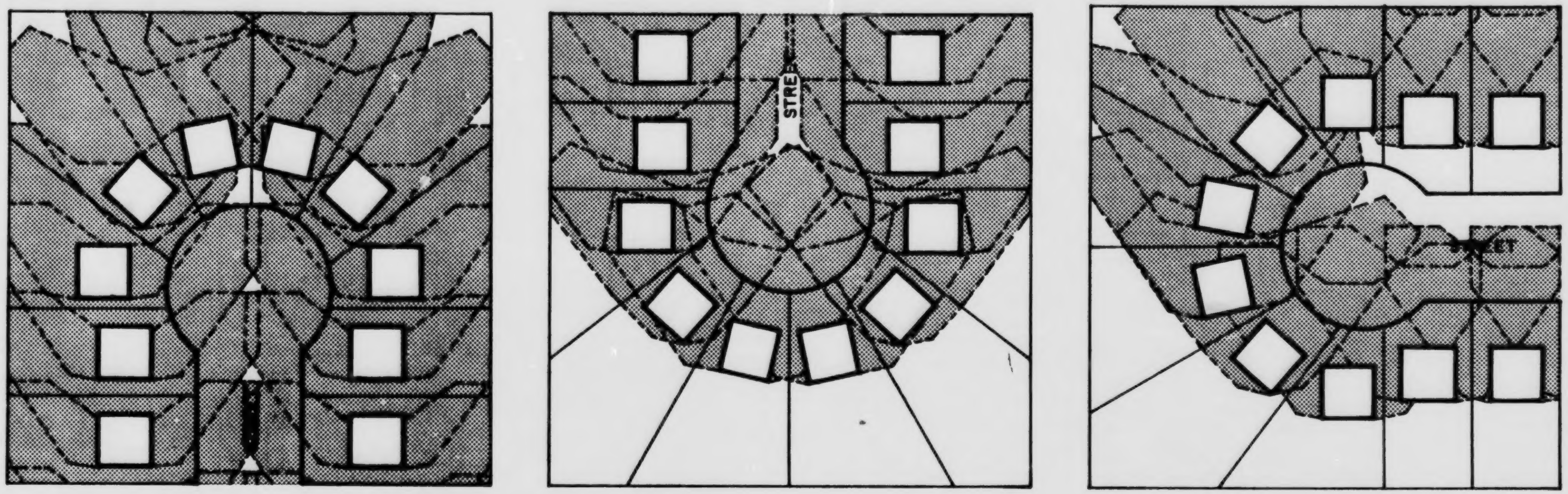
KEY LOT DESIGN (2 ROWS)

KEY LOT DESIGN (4 ROWS)

N

NORTH SOUTH STREET DESIGN

SHADOW CASTING ANALYSIS

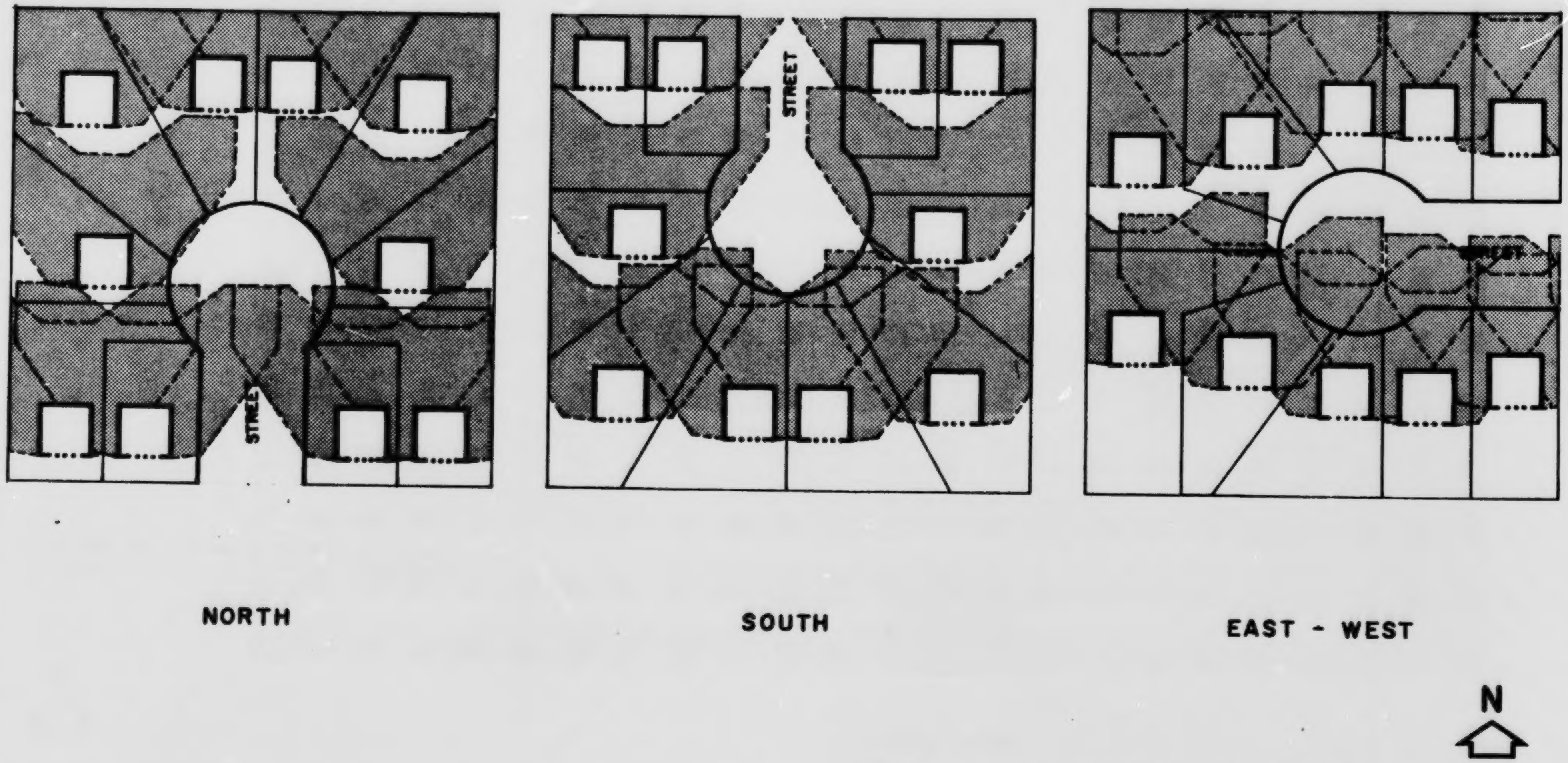

STRE
STREET

NORTH SOUTH EAST - WEST

N

CUL-DE-SAC : CONVENTIONAL DESIGN

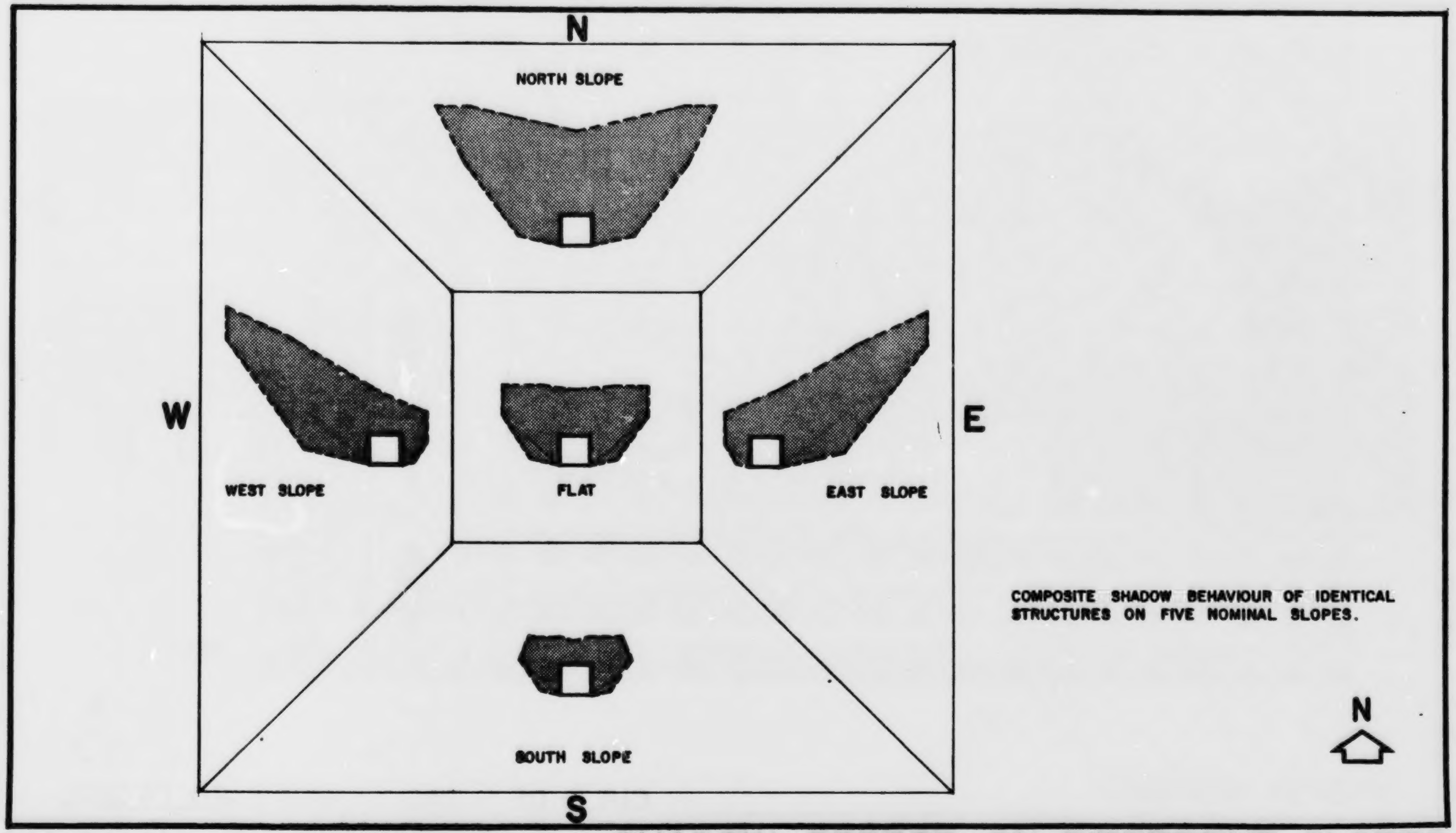
SHADOW CASTING ANALYSIS


STREET
STREET
STREET
N

NORTH SOUTH EAST - WEST

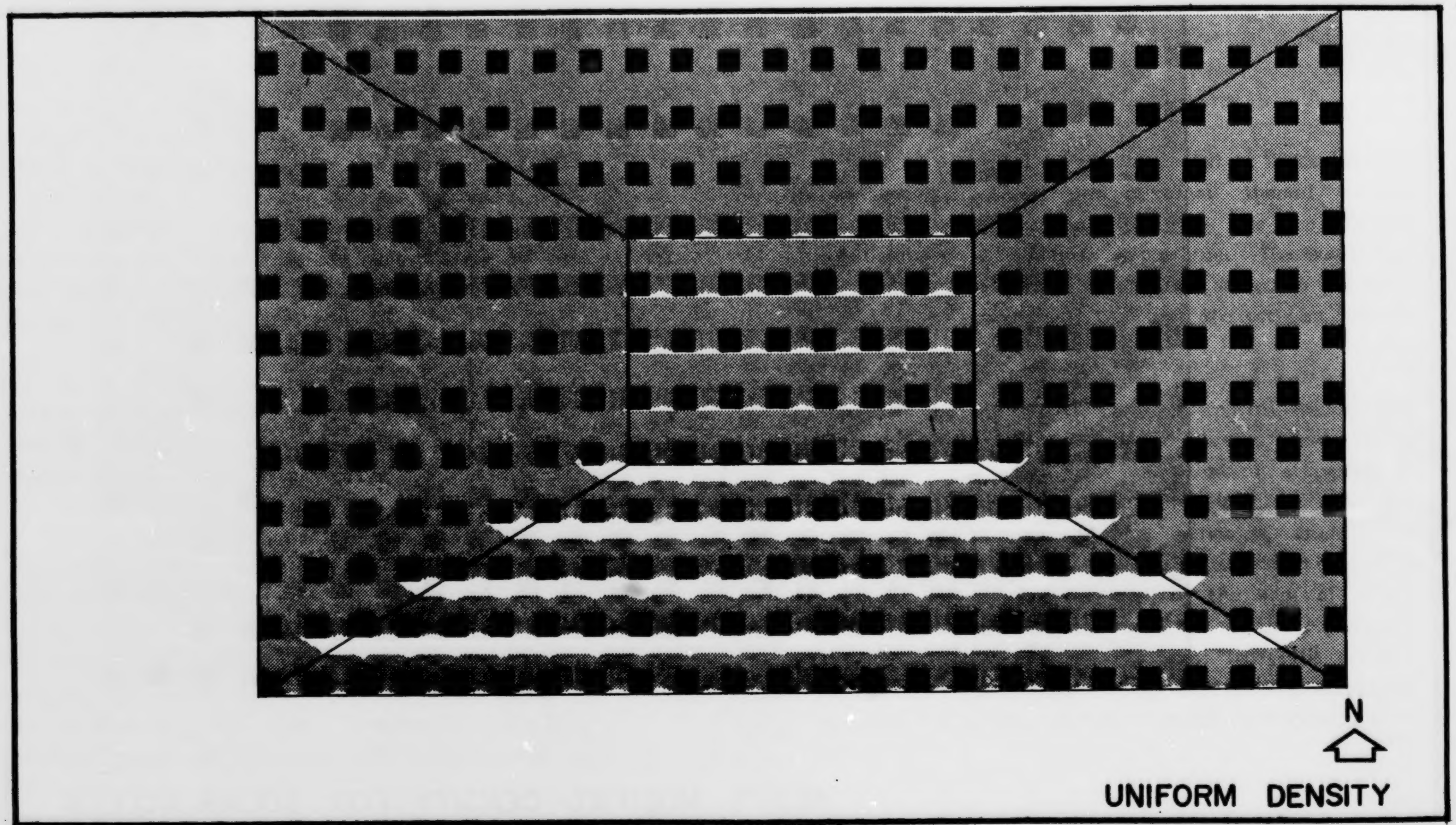
CUL - DE - SAC : MODIFIED DESIGN

SHADOW CASTING ANALYSIS

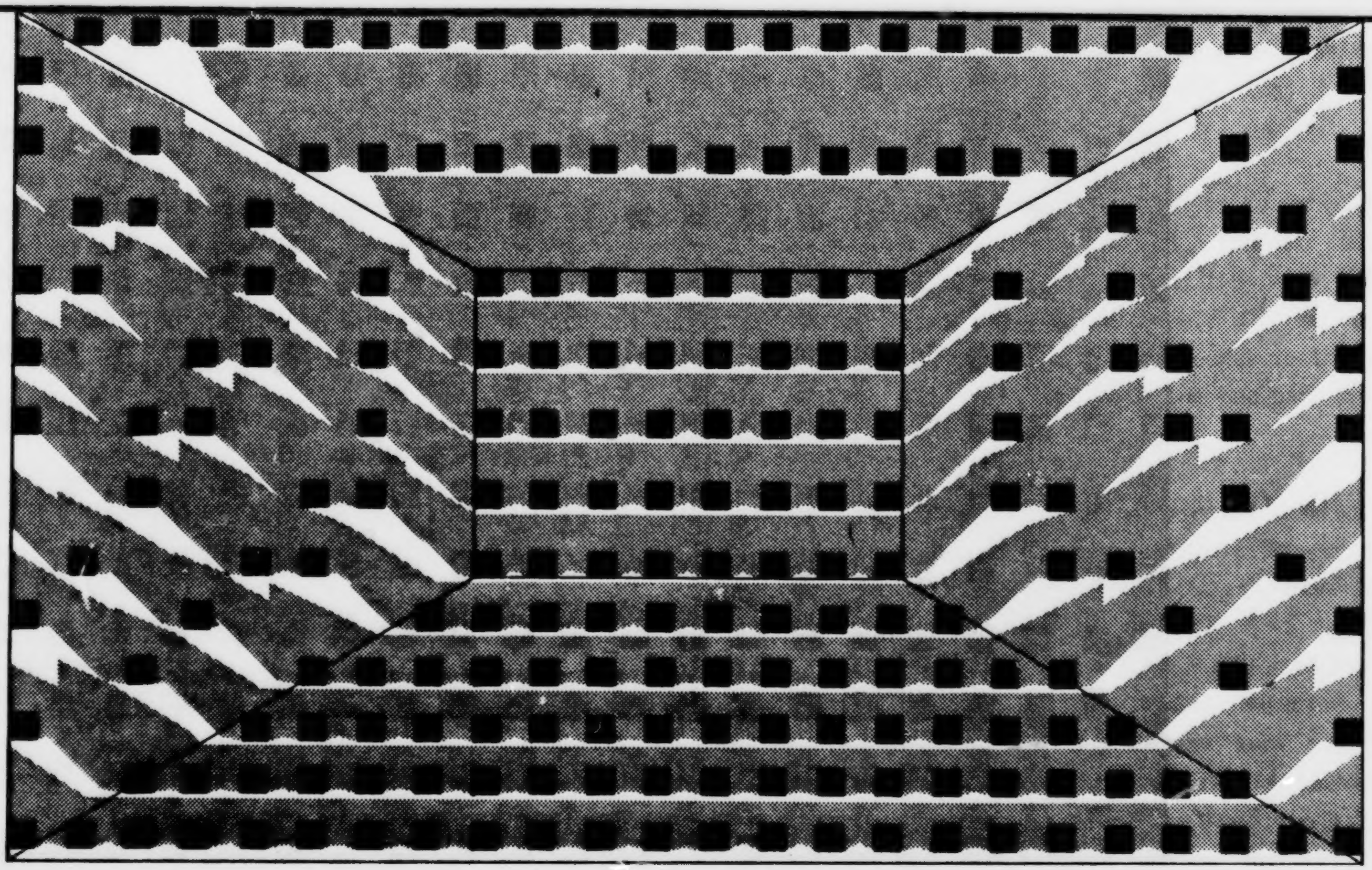

N
NORTH SLOPE
W
WEST SLOPE
FLAT
E
EAST SLOPE
SOUTH SLOPE
S
N

COMPOSITE SHADOW BEHAVIOUR OF IDENTICAL STRUCTURES ON FIVE NOMINAL SLOPES.

SHADOW EFFECT ON DIFFERENT SLOPES


N
UNIFORM DENSITY

COMPOSITE SHADOW EFFECT ON DIFFERENT SLOPES



SLOPE MODIFIED DENSITY FOR SOLAR ACCESS

COMPOSITE SHADOW EFFECT ON DIFFERENT SLOPES

The Ecochart is a design tool which has been constructed to reveal the uniqueness of the local climate and its dynamic variations in particular. A good understanding of the natural environment allows an architect or a planner to make very important conceptual decisions at an early design stage. As there are no two sites on earth which are identical, each house and each neighbourhood requires a special design strategy.

Time on the Ecochart is compressed. The magnitude of seasonal pounding passes with a blink of the eye. Flipping through Ecocharts is like travelling and experiencing all seasons concurrently.

The major design and planning decision is to determine the relationship to the sun: exactly how much of the annual and diurnal sun strokes can we utilize and how much would this solar furnace attachment cost in a wholistic energy account. There are many variables involved, such as the available and the actual number of sunshine hours, the year temperature profiles, topography, type of structure (s/v ratio), cost of insulation, building material, utilization of passive and active solar energy harvesting systems, cost of land, cost of manufactured and delivered energy, ...

Once it is established that the design is to be based on sun energy receivership (internal thermal balance sustained to a determined degree by the sun), shadow casting is no longer just a nuisance. The sun's rays become a most precious commodity and access to the sun a matter of life and death (for both the occupant and the building).

Consequently, the need to avoid and control shadows came with a sudden urgency. Escaping shadows became a new imperative. A handful of adventurists attempted to follow long forgotten ancient recipes. As with any obscured art, procedures were exchanged, traded, and copied. The pressures for inventing solutions were mounting, and tracing and copying the work of others escalated. Overloaded xerox machines are still producing new reports by recombining old ones. Thus, the transfer of knowledge and wisdom also carries misconceptions, mistakes, fallacies, oversights, errors, and omissions.

It has been quite rightfully concluded that a blanket regulation requiring a building structure to be totally exposed to the sun throughout the day and throughout the year might be self defeating. As a result, taking all the circumstances involved into account, the daily exposure time was narrowed down to the hours between 09:00 and 15:00. Similarly, it became obvious that, on an annual scale, an insistance on a twelve-month exposure requirement might lead, in some cases, to energy penalties instead of to energy gains.

In the hot cycle of the year, a reduction of exposure could be achieved by landscaping or by fixed and mobile shading devices. Blister prevention is a task left to the discretion of architects. However, the cold part of the year requires the attention of all the professionals involved. As demonstrated in the Ecochart analysis and in the Land Form Description exercise, first the basic design strategy has to be determined and hence the actual need for sun exposure. Only then can a planner determine the spatial relationships of individual developments. Thus, it would be utterly naive to impose regulations requiring spaces between buildings to be dictated by the length of the shadow on December 21st. It would be equally naive, however, to determine these spatial relationships by the shadows on January 21st, February 21st, March 21st . . . .

Energy conscious planning cannot be based on blanket provisions, but rather on performance standards, and on the selection of techniques achieving those standards. The design of a neighbourhood or a building must relate to its natural surroundings, to the diurnal and annual variations of the sun and to other forces put into motion by the sun.

There is an obvious need for a measuring system flexible enough to accommodate a variety of local environmental conditions, and a variety of designs and mechanical options. The length of the shadow on December 21st in combination with an Optional Grace Height is just such a metering device. It is described in detail on the following pages.

The advantages of this method can be summarized as follows:

1. the distance between structures is determined by two components:

   i) the length of the December 21st shadow (varies according to the latitude and the topography),

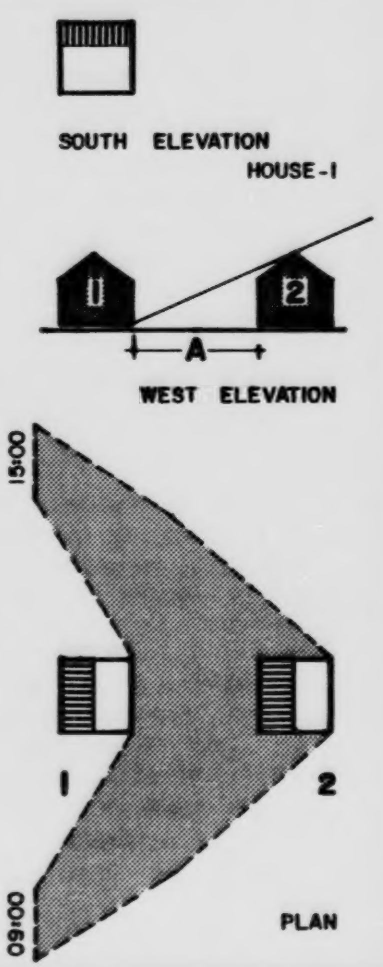
   ii) the optimal grace height (varies according to planner's or architect's specifications;

2. it provides for a precise control of the shadow situation in a cold annual cycle (finer performance calculations are possible);

3. it provides for local environmental oddities and yet it has a universal (continental) application; and

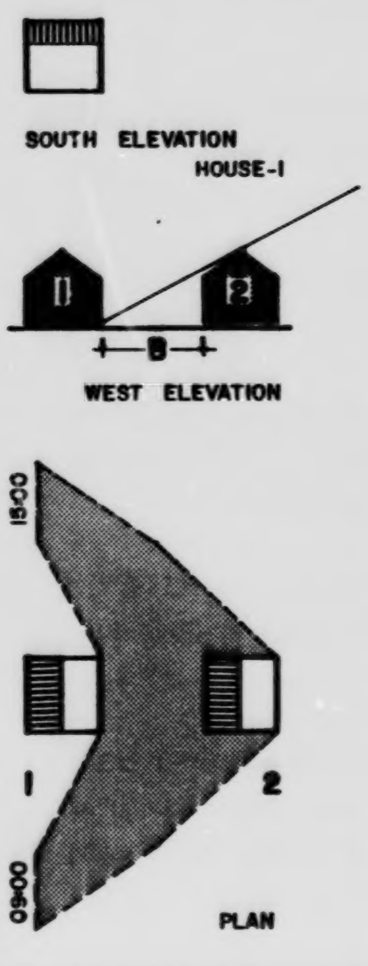
4. it provides for the advent of new advanced solar energy harnessing systems and the subsequent retrofitting and upgrading of solar harnessing capacity.

DECEMBER 21

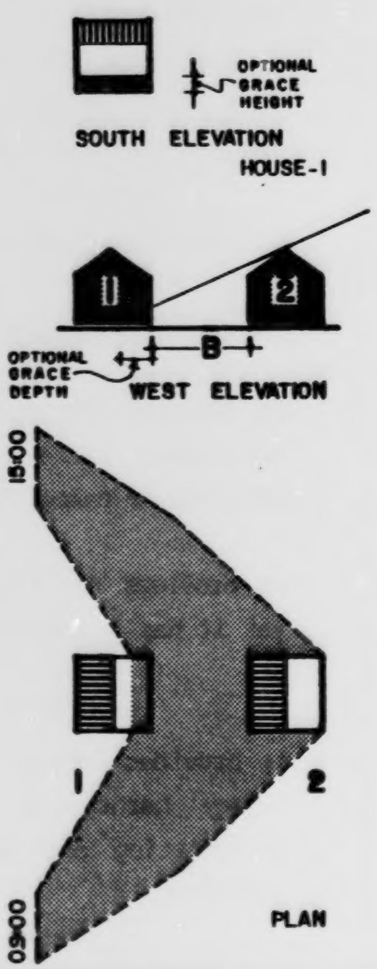

SOUTH ELEVATION
HOUSE-1
1
2
A
WEST ELEVATION
15:00
09:00
1
2
PLAN

IF WE ARE REQUESTING NO SHADOW CASTING DURING 0900 — 1500 HOURS, THEN THE DISTANCE BETWEEN HOUSE NO. 1 AND NO. 2 IS EQUAL TO "A".

JANUARY 21 & NOVEMBER 21


SOUTH ELEVATION
HOUSE-1
1
2
B
WEST ELEVATION
15:00
09:00
1
2
PLAN

DECEMBER 21


OPTIONAL GRACE HEIGHT
SOUTH ELEVATION
HOUSE-1
1
2
OPTIONAL GRACE DEPTH
B
WEST ELEVATION
15:00
09:00
1
2
PLAN

NOTE: DECEMBER AS A METER OF SOLAR ACCESS — THESE DIAGRAMS ILLUSTRATE HOW A VARIETY OF SPATIAL RELATIONSHIPS (DISTANCES) ARE EXPRESSED IN TERMS OF "DECEMBER".

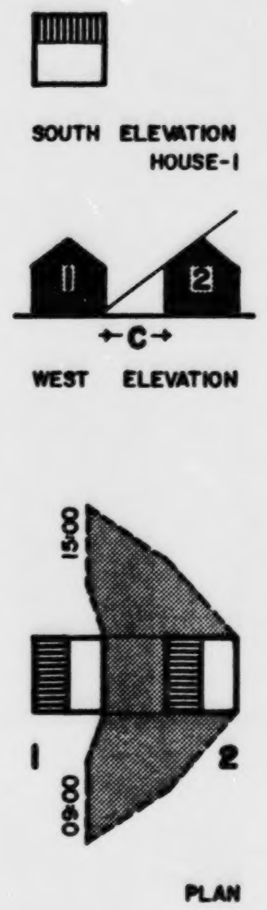
N

IF IT IS DETERMINED THAT DISTANCE "A" IS NOT ECONOMICALLY JUSTIFIABLE (IE.: DECEMBER MAY BE TOO CLOUDY TO JUSTIFY THE SPATIAL REQUIREMENTS FOR NO SHADING), REQUIRE THAT NO SHADOW CASTING TAKE PLACE BETWEEN THE HOURS OF (09:00-15:00) IN JANUARY/NOVEMBER.

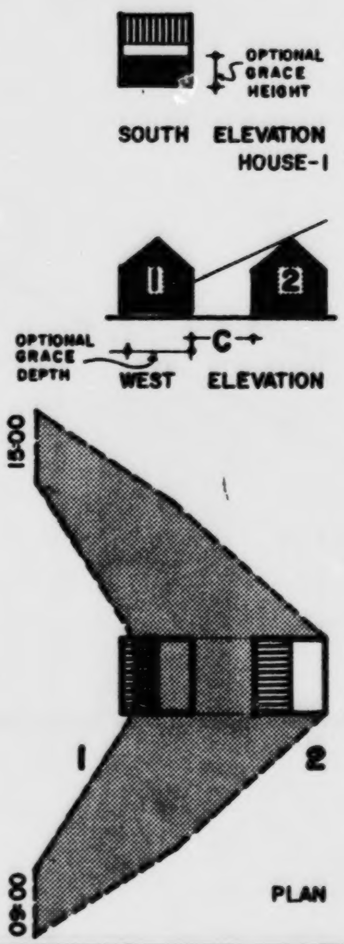
THIS WILL MAKE THE DISTANCE BETWEEN HOUSE NO. 1 AND NO. 2 EQUAL TO "B".

HOWEVER, DISTANCE "B" SHOULD BE ARRIVED AT BY USING THE DECEMBER TEMPLATE TO MEASURE THE DEGREE OF SHADING, BY THE INTRODUCTION OF THE "OPTIONAL GRACE HEIGHT", THAT IS THE HEIGHT THE SHADOW IS PERMITTED TO CLIMB ON THE WALL, OR BY THE INTRODUCTION OF THE "OPTIONAL GRACE DEPTH", THAT IS THE DEPTH TO WHICH THE SHADOW IS PERMITTED TO PENETRATE INSIDE THE HOUSE.

FEBRUARY 21 & OCTOBER 21

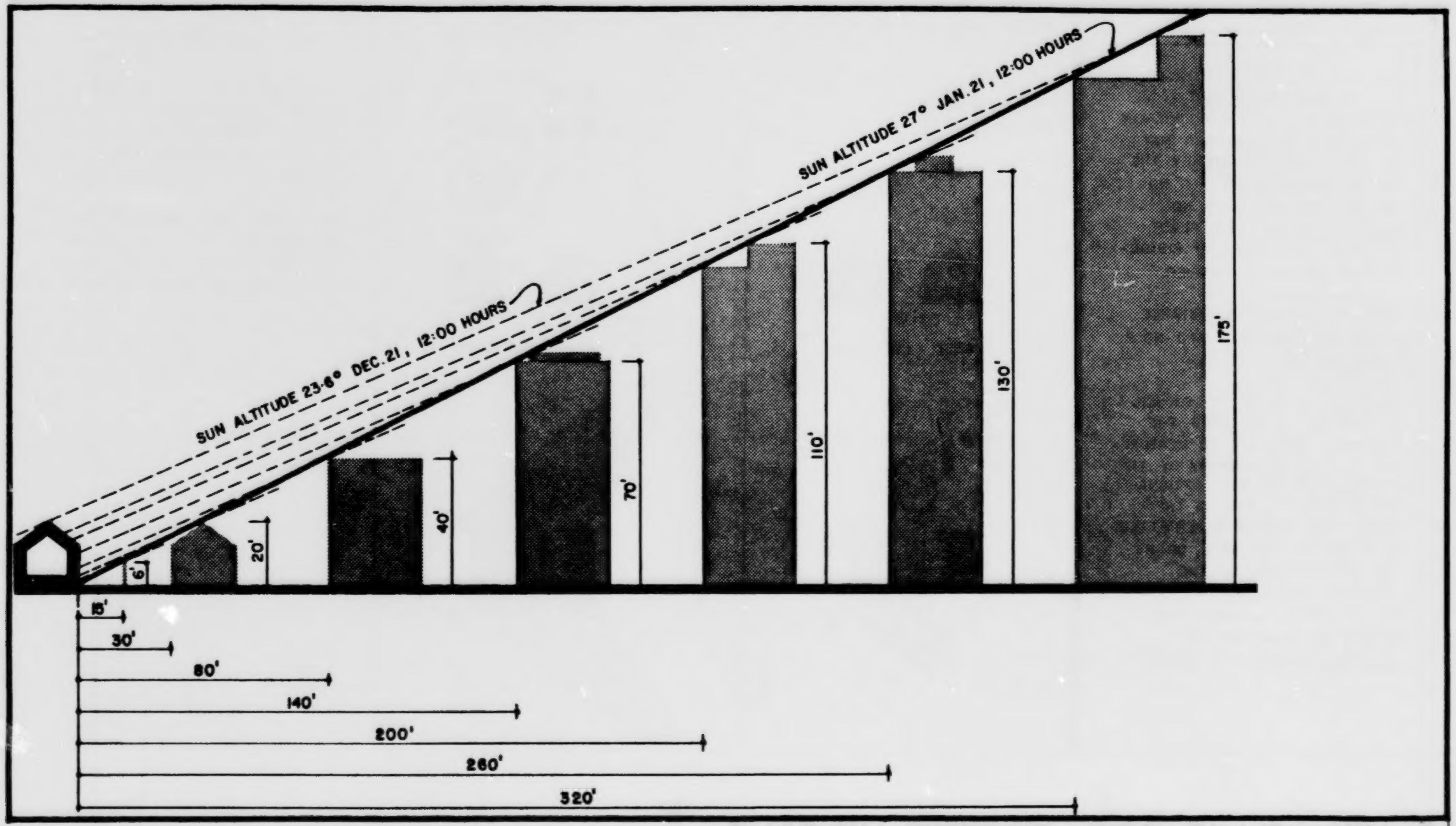

SOUTH ELEVATION
HOUSE-1
1
2
←C→
WEST ELEVATION
15:00
09:00
1
2
PLAN

DECEMBER 21

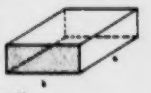
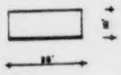
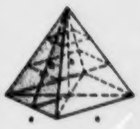
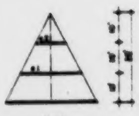
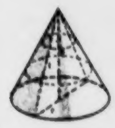
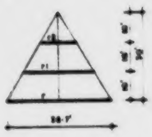
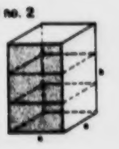
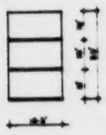
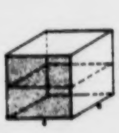
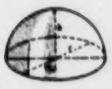
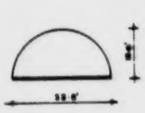
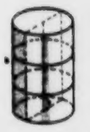
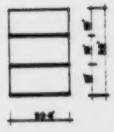
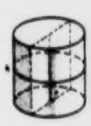
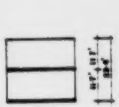
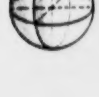
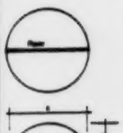
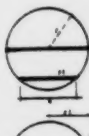
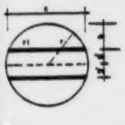
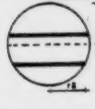

OPTIONAL GRACE HEIGHT
SOUTH ELEVATION
HOUSE-1
1
2
OPTIONAL GRACE DEPTH
←C→
WEST ELEVATION
15:00
09:00
1
2
PLAN

A REQUEST THAT NO SHADOW CASTING TAKE PLACE (09:00-15:00) IN FEB./OCT. WILL RESULT IN AN EVEN SHORTER DISTANCE BETWEEN HOUSE NO. 1 AND NO. 2.

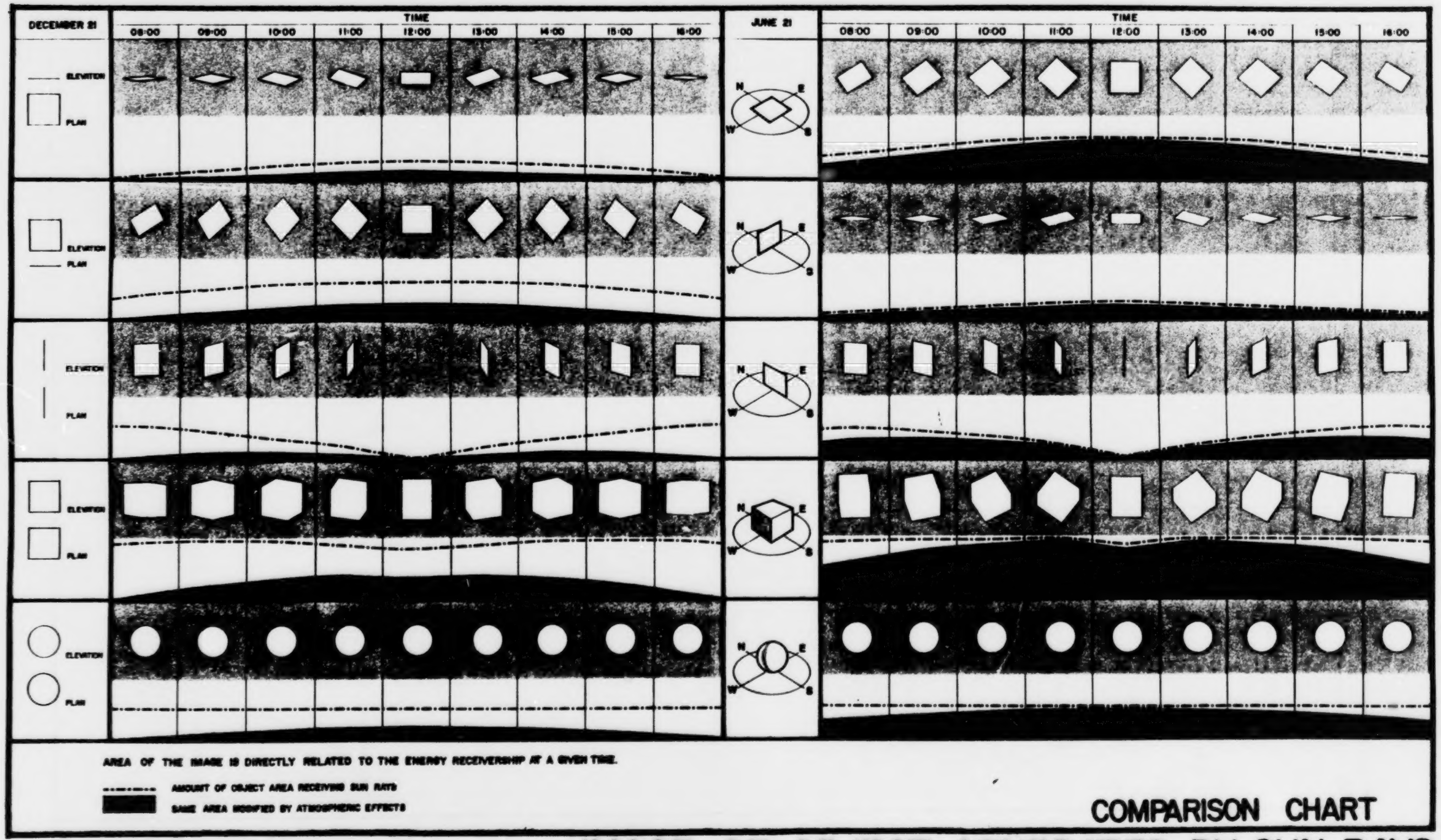
AGAIN, WE SHALL EXPRESS THE DISTANCE "C" IN TERMS OF THE "OPTIONAL GRACE HEIGHT" OR THE "OPTIONAL GRACE DEPTH".


SUN ALTITUDE 23.6° DEC. 21, 12:00 HOURS
SUN ALTITUDE 27° JAN. 21, 12:00 HOURS
6'
20'
40'
70'
110'
130'
175'
15'
30'
80'
140'
200'
260'
320'

SHADOW EFFECT: DEC. 21 VS. JAN. 21

	SHAPE	VOLUME	SURFACE	POSSIBLE FLOOR SPACE	VOLUME SURFACE EFFICIENCY
1	PARALLELOPIPED no. 1  h = 10' a = 40' b = 25'	10,000 cu.ft. 283 m^3	3300 sq.ft. 306·6 m^2	1000 sq.ft. 93 m^2 	68·01 %
2	PYRAMID  h = 30' a = 31·6' b = 33·9'	10,000 cu.ft.	3144·7 sq.ft. 292·2 m^2	1555·5 sq.ft. 144·5 m^2 a1 = 21·1' a2 = 10·5' 	71·37 %
3	CONE  h = 30' r = 17·8' l = 34·9'	10,000 cu.ft.	2956·4 sq.ft. 274·6 m^2	1555·5 sq.ft. 144·5 m^2 r1 = 11·9' r2 = 5·9' 	73·92 %
4	PARALLELOPIPED no. 2  a = 18·3' b = 30'	10,000 cu.ft.	2857·5 sq.ft. 265·5 m^2	1000 sq.ft. 93 m^2 	78·55 %
5	CUBE  a = 21·5'	10,000 cu.ft.	2784·9 sq.ft. 258·7 m^2	928·3 sq.ft. 86·2 m^2	80·60 %
6	HEMISPHERE  h = 16·9' r = 16·9'	10,000 cu.ft.	2676·1 sq.ft. 248·6 m^2	892·0 sq.ft. 82·9 m^2 	83·67 %
7	CYLINDER  h = 30' r = 10·3'	10,000 cu.ft.	2608·1 sq.ft. 242·3 m^2	1000 sq.ft. 93 m^2 	86·06 %
8	RIGHT CYLINDER  h = 23·4' r = 11·7'	10,000 cu.ft.	2569·5 sq.ft. 238·7 m^2	856·5 sq.ft. 79·6 m^2 	87·35 %
9	SPHERE  r = 13·4'	10,000 cu.ft.	2244·6 sq.ft. 208·5 m^2	 561·2 sq.ft. 52·1 m^2  808·16 sq.ft. 75·1 m^2 b = r - 10 = 3·4' c = 17·7' $r1 = \frac{c}{2}$ = 8·9'  965·24 sq.ft. c = 24·8' $r1 = \frac{c}{2}$ = 12·4' b = 8·4'  940·11 sq.ft. b1 = r - 3 = 10·4' b2 = r - 7 = 6·4' r1 = 13·0' r2 = 11·4'	100 %

SURFACE / VOLUME RATIO OF DIFFERENT SOLIDS



AREA OF THE IMAGE IS DIRECTLY RELATED TO THE ENERGY RECEIVERSHIP AT A GIVEN TIME.

-·-·-·- AMOUNT OF OBJECT AREA RECEIVING SUN RAYS

■ SAME AREA MODIFIED BY ATMOSPHERIC EFFECTS

COMPARISON CHART

IMAGE OF OBJECT GENERATED BY SUN RAYS

METHOD OF CALCULATION OF APPARENT SOLAR TIME

The whole North American Continent is divided into six time zones: Newfoundland, Atlantic, Eastern, Central, Mountain and Pacific.

The Central Longitudes (Reference Lines) of these zones are:

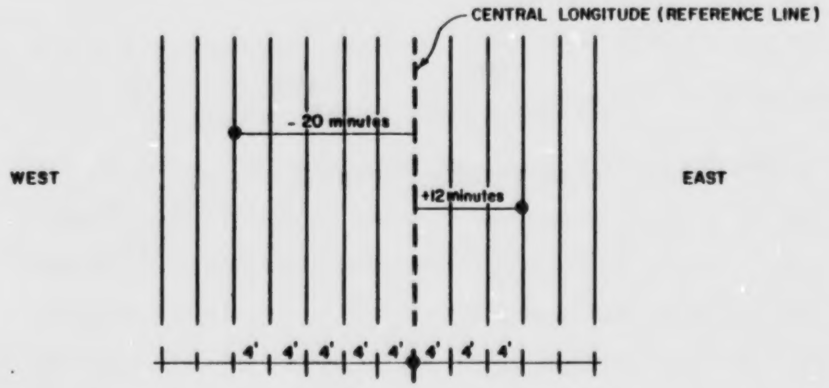
52.5° Longitude - Newfoundland Standard Time
60° " - Atlantic " "
75° " - Eastern " "
90° " - Central " "
105° " - Mountain " "
120° " - Pacific " "

The precise calculation of solar time is very complex. However, the following simple method is sufficiently accurate for architect, planner or design professional.

Step 1: During daylight saving time (last Sunday of April to last Sunday of October), subtract one hour from local time (local time is shown by your watch). This gives you the standard time.

Step 2. Add four minutes to the standard time for every degree of longitude if the site is east of the Central Longitude (Reference Line) or;

Subtract four minutes for every degree of longitude if the site is west of the Central Longitude (Reference Line).


CENTRAL LONGITUDE (REFERENCE LINE)
WEST
EAST
- 20 minutes
+12 minutes
4'
4'
4'
4'
4'
4'
4'
4'

Step 3. Correct seasonal variations of the earth-sun geometry by adding or subtracting the following times:

		Minutes	Seconds			Minutes	Seconds
January	21	-11	23	July	21	-06	19
February	"	-13	39	August	"	-03	04
March	"	-07	12	September	"	+06	57
April	"	+01	19	October	"	+15	22
May	"	+03	30	November	"	+14	07
June	"	-01	40	December	"	+01	53

EXAMPLE:

To calculate the solar time for Hamilton, Ontario at 12:00:00 hours (Hours:Minutes:Seconds) local time on June 21st -

We know that:
- Local time is the time shown by your watch;
- Daylight saving time is in effect from the last Sunday in April to the last Sunday in October;
- Hamilton's longitude is 80° West, thus,
- Hamilton is located within the Eastern Standard Time Zone;
- The Eastern Standard Time Zone has its Central Longitude (Reference Line) at 75°, thus,
- Hamilton is located 5° West of the Central Longitude (Reference Line);
- The seasonal variation for June 21st is 00:01:40 (one minute, forty seconds).

Calculation:

Step 1. In June, Daylight Saving Time is in effect; thus, we have to subtract one hour from the local time:

12:00:00 (Local Time) - 01:00:00 = 11:00:00 hours (Standard Time)

Step 2. Subtract four minutes for each degree of longitude from 1100 hours

5 degrees x 4 minutes = 20 minutes

11:00:00 hours - 20 minutes = 10:40:00 (10 hours, 40 minutes)

Step 3: Subtract the seasonal variation for June 21:

10:40:00 - 00:01:40 = 10:38:20

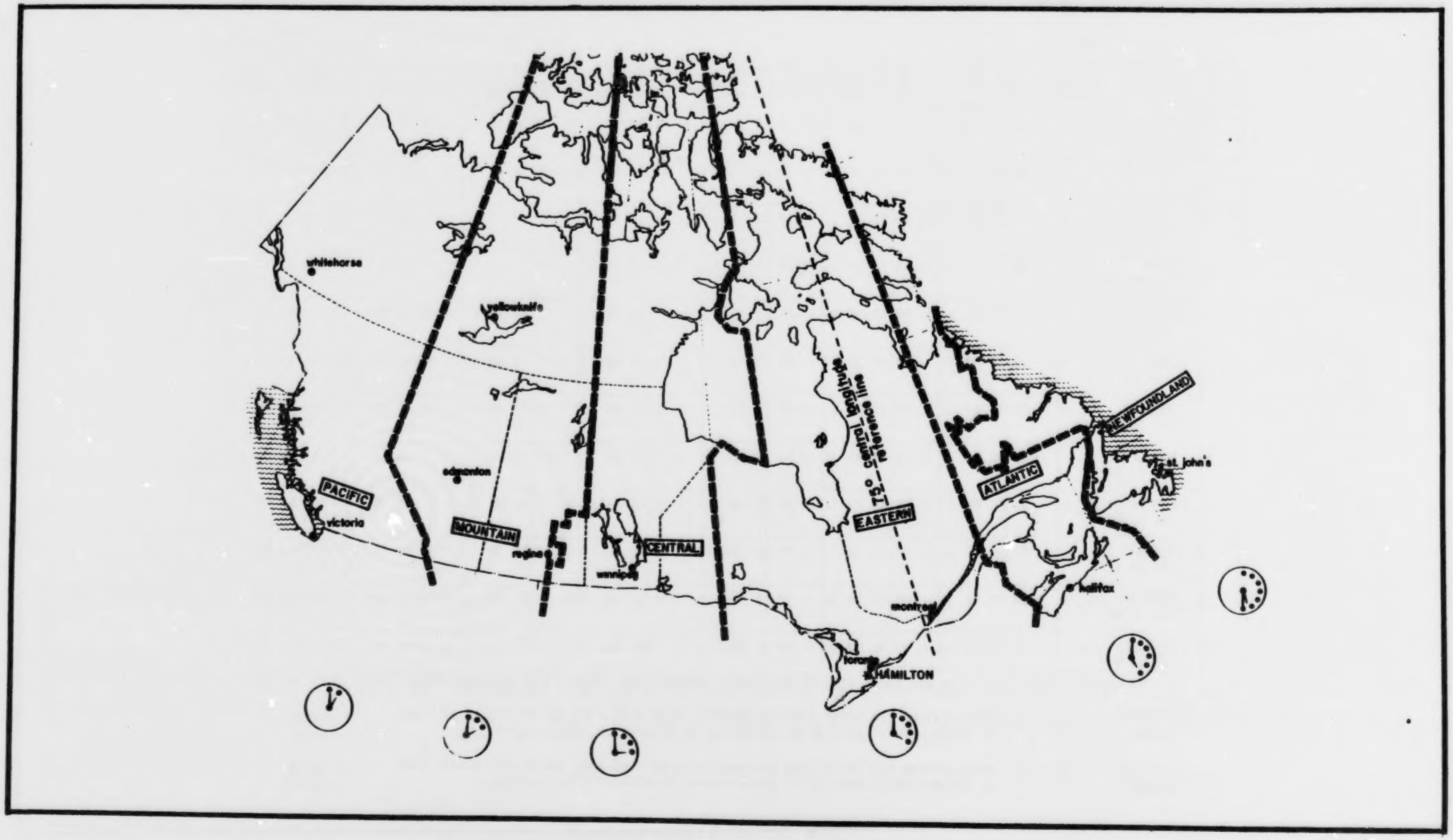
(10 hours 40 minutes A.M., minus 1 minute and 40 seconds equals 10 hours, 38 minutes and 20 seconds)

Answer: June 21st, Hamilton, Ontario

Noon (12:00:00 hours local time) = 10 hours, 38 minutes, and 20 seconds Solar Time.

Note: The difference between local time and solar time is 1 hour, 21 minutes and 40 seconds. This is the constant difference throughout the whole 21st day of June.

Thus, solar noon would take place when our watch shows 1 hour, 21 minutes and 40 seconds P.M. (that is 13:21:40 local time). At this time any given object would cast the shortest shadow of the day. Interestingly, June 21st happened to be the longest day of the year; thus, the shortest shadow of the 21st day of June would also be the shortest shadow of the year.


whitehorse
yellowknife
edmonton
victoria
PACIFIC
MOUNTAIN
regina
winnipeg
CENTRAL
75° central longitude reference line
EASTERN
montreal
toronto
HAMILTON
ATLANTIC
NEWFOUNDLAND
st. john's
halifax

TIME ZONES

For Hamilton: 43° North Latitude
80° West Longitude

LOCAL TIME	09 00 00	10 00 00	11 00 00	12 00 00	13 00 00	14 00 00	15 00 00
	SOLAR TIME	SOLAR TIME	SOLAR TIME	SOLAR TIME	SOLAR TIME	SOLAR TIME	SOLAR TIME
JANUARY 21 -00 31 24*	08 28 36	09 28 36	10 28 36	11 28 36	12 28 36	13 28 36	14 28 36
FEBRUARY 21 -00 33 48*	08 26 12	09 26 12	10 26 12	11 26 12	12 26 12	13 26 12	14 26 12
MARCH 21 -00 27 24*	08 32 36	09 32 36	10 32 36	11 32 36	12 32 36	13 32 36	14 32 36
APRIL 21 -00 18 48*	08 41 12	09 41 12	10 41 12	11 41 12	12 41 12	13 41 12	14 41 12
MAY 21 -01 16 24*	07 43 36	08 43 36	09 43 36	10 43 36	11 43 36	12 43 36	13 43 36
JUNE 21 - 01 21 30*	07 38 30	08 38 30	09 38 30	10 38 30	11 38 30	12 38 30	13 38 30
JULY 21 -01 26 12*	07 33 48	08 33 48	09 33 48	10 33 48	11 33 48	12 33 48	13 33 48
AUGUST 21 -01 23 06*	07 36 54	08 36 54	09 36 54	10 36 54	11 36 54	12 36 54	13 36 54
SEPTEMBER 21 -01 13 12*	07 46 48	08 46 48	09 46 48	10 46 48	11 46 48	12 46 48	13 46 48
OCTOBER 21 -01 04 42*	07 55 18	08 55 18	09 55 18.	10 55 18	11 55 18	12 55 18	13 55 18
NOVEMBER 21 -00 34 06*	08 25 54	09 25 54	10 25 54	11 25 54	12 25 54	13 25 54	14 25 54
DECEMBER 21 -00 18 00*	08 42 00	09 42 00	10 42 00	11 42 00	12 42 00	13 42 00	14 42 00

* To convert solar time from any local time on this date, deduct this figure (e.g. February 21st, is 00 33 48 hr. min. sec)

EXAMPLE: 1. What will be the solar time on January 21 at 9:00 a.m. (09 00 00) local time?
ANSWER: 09 00 00 - 00 31 24 = 08 28 36 (8 hours, 28 minutes, 36 seconds)

EXAMPLE: 2. What will be the solar time on January 21 at 9:25 a.m. (09 25 00) local time?
ANSWER 09 25 00 - 00 31 24 = 08 53 36 (8 hours, 53 minutes, 36 seconds)

CONVERSION FROM LOCAL TO SOLAR TIME

For Hamilton: 43° North Latitude
80° West Longitude

SOLAR TIME	09 00 00	10 00 00	11 00 00	12 00 00	13 00 00	14 00 00	15 00 00
	LOCAL TIME	LOCAL TIME	LOCAL TIME	LOCAL TIME	LOCAL TIME	LOCAL TIME	LOCAL TIME
JANUARY 21 +00 31 24*	09 31 24	10 31 24	11 31 24	12 31 24	13 31 24	14 31 24	15 31 24
FEBRUARY 21 +00 33 48*	09 33 48	10 33 48	11 33 48	12 33 48	13 33 48	14 33 48	15 33 48
MARCH 21 +00 27 24*	09 27 24	10 27 24	11 27 24	12 27 24	13 27 24	14 27 24	15 27 24
APRIL 21 +00 18 48*	09 18 48	10 18 48	11 18 48	12 18 48	13 18 48	14 18 48	15 18 48
MAY 21 +01 16 24*	10 16 24	11 16 24	12 16 24	13 16 24	14 16 24	15 16 24	16 16 24
JUNE 21 +01 21 30*	10 21 30	11 21 30	12 21 30	13 21 30	14 21 30	15 21 30	16 21 30
JULY 21 +01 26 12*	10 26 12	11 26 12	12 26 12	13 26 12	14 26 12	15 26 12	16 26 12
AUGUST 21 +01 23 06*	10 23 06	11 23 06	12 23 06	13 23 06	14 23 06	15 23 06	16 23 06
SEPTEMBER 21 +01 13 12*	10 13 12	11 13 12	12 13 12	13 13 12	14 13 12	15 13 12	16 13 12
OCTOBER 21 +01 04 42*	10 04 42	11 04 42	12 04 42	13 04 42	14 04 42	15 04 42	16 04 42
NOVEMBER 21 +00 34 06*	09 34 06	10 34 06	11 34 06	12 34 06	13 34 06	14 34 06	15 34 06
DECEMBER 21 +00 18 00*	09 18 00	10 18 00	11 18 00	12 18 00	13 18 00	14 18 00	15 18 00

* To convert local time from any solar time on this date, add this figure (e.g. January 21st, is 00 31 24 hr. min. sec.)

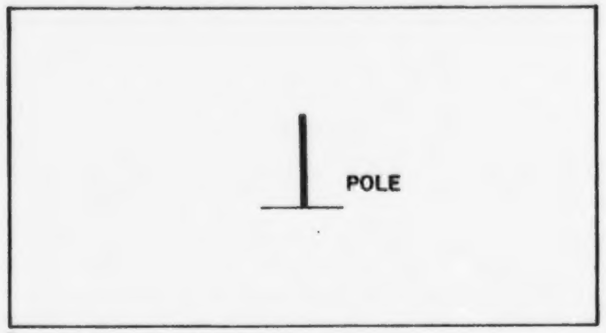
EXAMPLE: 1. What will be the local time on January 21 at 3:00 p.m. (15 00 00) solar time?
ANSWER: 15 00 00 + 00 31 24 = 15 31 24 (3 hours, 31 minutes, 24 seconds)

EXAMPLE: 2. What will be the local time on January 21 at 2:45 p.m. (14 45 00) solar time?
ANSWER: 14 45 00 + 00 31 24 = 15 16 24 (3 hours, 16 minutes, 24 seconds)

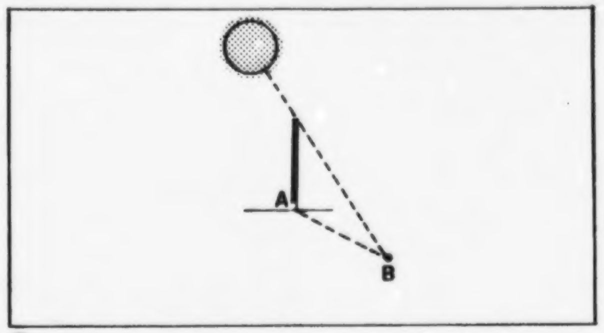
CONVERSION FROM SOLAR TO LOCAL TIME

CONSTRUCTION OF 'TRUE NORTH'- VITRUVIAN METHOD

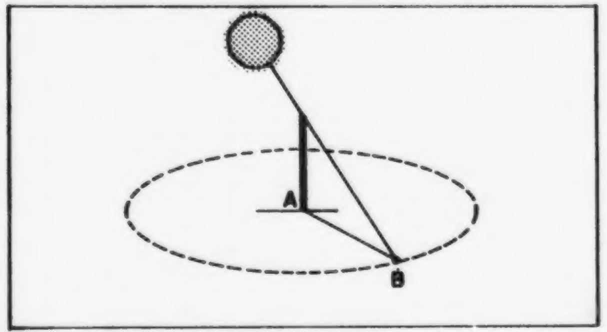
'TRUE NORTH' IS THE DIRECTION TOWARDS THE GEOGRAPHIC NORTH (EARTH'S AXIX).
'MAGNETIC NORTH', USED BY SURVEYORS, IS THE DIRECTION SHOWN BY A MAGNETIC COMPASS.
SOLAR AZIMUTH, (AS ON OUR SHADOW TEMPLATES), IS ALWAYS MEASURED FROM 'TRUE NORTH'.
'TRUE NORTH' ALSO CAN BE CONSTRUCTED ACCORDING TO THE DIRECTIONS ON THIS PAGE.
ALTHOUGH IT WAS INTRODUCED BY THE ROMAN ARCHITECT VITRUVIUS, (FIRST CENTURY B.C.), THIS METHOD WAS DEFINITELY KNOWN AND USED BY ANCIENT BABYLONIAN AND EGYPTIAN ASTRONOMERS.



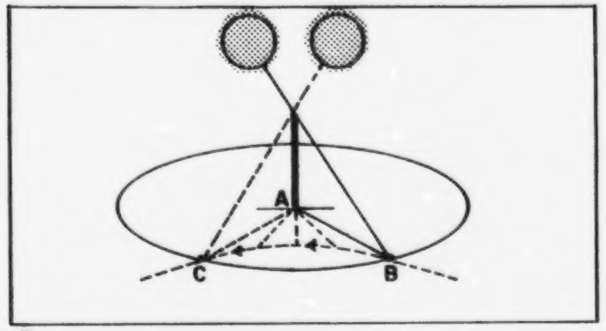
1. PLACE A POLE IN THE GROUND.



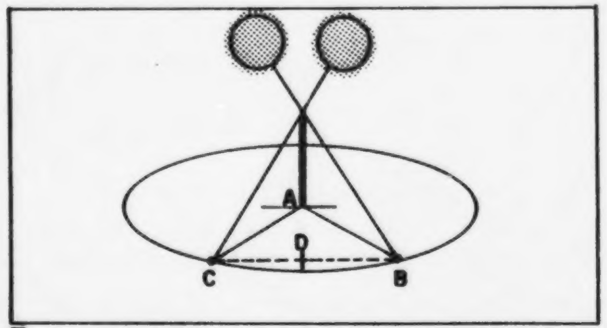
2. IN THE MORNING, MARK THE END OF ITS SHADOW. 'A B' IS THE SHADOW OF THE POLE.



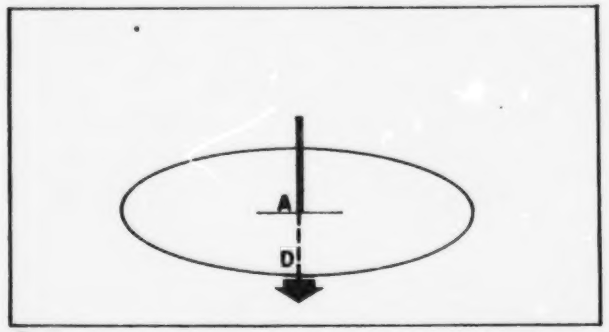
3. 'A' AS CENTRE 'A B' AS RADIUS, DRAW A CIRCLE ON THE GROUND.



4. IN THE AFTERNOON, WHEN THE END OF THE SHADOW FALLS RIGHT ON THE CIRCLE, MARK IT AS 'C'.



5. DIVIDE THE DISTANCE 'C B' IN HALF AT POINT 'D'.



6. JOIN 'A D'. THIS LINE FROM 'A' TO 'D' POINTS TRUE NORTH.

TRUE NORTH

Part Four

Policies and Guidelines

DISCUSSION

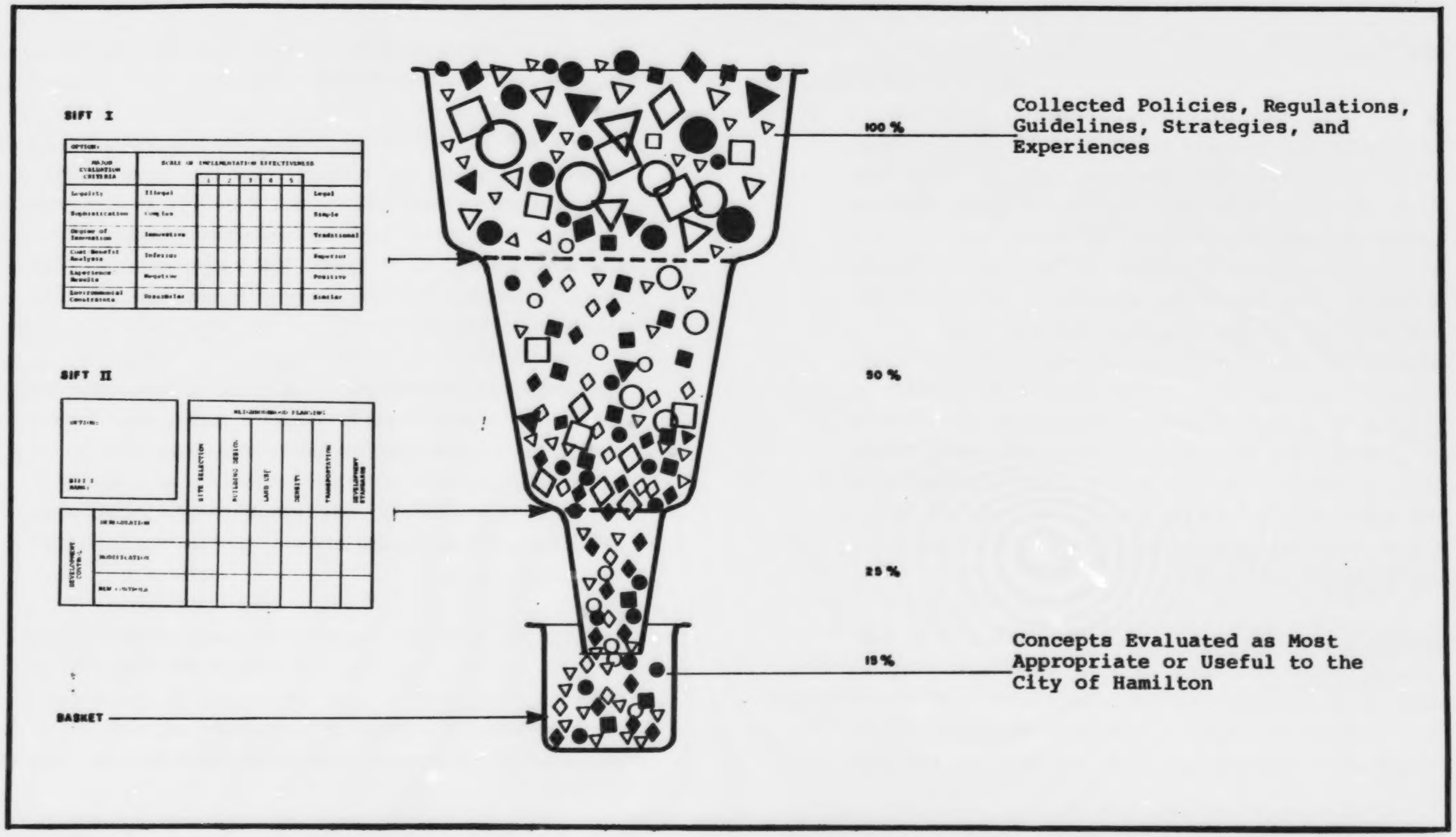
Of the total time and effort devoted to Stage One, a large amount was consumed in our quest to identify energy efficient neighbourhood planning measures throughout North America. There is a wealth of energy planning information that till recently has passed unknown. Many of the principles, discarded in our era of energy affluence, have had to be relearned. The novelty and complexity of energy planning dictates that no one municipality can develop an omni-cure for our energy disease. Just as parts of this study will hopefully be modified by readers to develop answers specific to their environment, the solutions to energy efficiency evolve from the process of innovation. In order to benefit from the experiences of others, and not recreate the wheel, energy saving policies and practices of other communities were collected and reviewed.

Ideally, this "shopping" for concepts should have been extended beyond the bounds of North Amercia to cultures where energy planning has always been considered a norm (e.g. Greece or Japan). However, this would have significantly enlarged our scope and required resources beyond the limits of this project. Such an undertaking is suggested for further study.

Of the one hundred or so investigations performed, a selection of thirty has been included in Appendix "C". This selection is not a "best of"; rather it is a mixture of concepts highlighting the numerous approaches that have evolved. This reflects the relative novelty of energy planning, and the wildly ranging inherent site specific constraints.

The evaluation process is exemplified by the following schematic. Together with a number of energy planning and design concepts devised by the study (PART THREE), the collected experiences of other communities were placed in the Analytical Matrix and evaluated for conceptual effectiveness and appropriateness for implementation in Hamilton.

The Analytical Matrix basically consists of SIFT I and SIFT II. Once a concept has been identified, it is placed in the mouth of the matrix; if it successfully passes through the "coarse" evaluation of SIFT I, it proceeds to the "finer" evaluation of SIFT II. Those


SIFT I
OPTION:
MAJOR EVALUATION CRITERIA
SCALE OF IMPLEMENTATION EFFECTIVENESS
1
2
3
4
5
Legality
Illegal
Legal
Sophistication
Complex
Simple
Degree of Innovation
Innovative
Traditional
Cost Benefit Analysis
Inferior
Superior
Experience Results
Negative
Positive
Environmental Constraints
Dissimilar
Similar
SIFT II
OPTION:
SIFT I RANK:
NEIGHBOURHOOD PLANNING
SITE SELECTION
BUILDING DESIGN
LAND USE
DENSITY
TRANSPORTATION
DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL
DEREGULATION
MODIFICATION
NEW CONTROLS
BASKET
100 %
50 %
25 %
15 %

Collected Policies, Regulations, Guidelines, Strategies, and Experiences

Concepts Evaluated as Most Appropriate or Useful to the City of Hamilton

ANALYTICAL MATRIX SCHEMATIC

concepts which filter through the matrix, ending up in the "basket", are considered most appropriate and are formulated into policies and strategies specific to neighbourhood development in Hamilton.

For economic, cultural or climatological reasons, many of the concepts which entered the matrix could have been dismissed without evaluation, while those that seemed appropriate proved otherwise under evaluation. Therefore, all concepts to be considered were placed through the matrix. The coarse evaluation (SIFT I) was designed around three prime factors: accuracy, relevant data, and a significant sift or cut in quantity. These factors were achieved by the following criteria:

i) legality,
ii) sophistication,
iii) cost/benefits,
iv) environmental constraints,
v) degree of innovation, and
vi) experience and results.

SIFT I provided the study with an initial selection of concepts that were further evaluated in two ways, SIFT II:

i) According to their particular effects on development control:

- deregulation,
- modification,
- new controls.

ii) According to their particular effect on neighbourhood planning:

- site selection,
- building design,
- land use,
- density,
- transportation,
- development standards.

The SIFT II evaluations form recurring themes in policy phasing (page 154) and determining those neighbourhood planning issues most affected by energy efficient development. Those concepts which successfully filter through the matrix become tailored to neighbourhood development in Hamilton.

SIFT I

OPTION:							
MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS						
		1	2	3	4	5	
Legality	Illegal						Legal
Sophistication	Complex						Simple
Degree of Innovation	Innovative						Traditional
Cost/Benefit Analysis	Inferior						Superior
Experience/ Results	Negative						Positive
Environmental Constraints	Dissimilar						Similar

LEGALITY

- this criteria measures the conformity of the option to Hamilton's existing legal framework.
- a ranking of five indicates that the option may be implemented without requiring amendments, revisions, or new legislation.
- a ranking of one indicates that the option could only be implemented if the municipality was granted additional powers.

SOPHISTICATION

- this criteria measures the intellectual development of the option and the basis of its logic in formulation, interpretation, implementation, and enforcement.
- a ranking of five indicates a relatively high degree of ingenious simplicity.
- a ranking of one indicates a relatively high degree of impeding complexity.

COST/BENEFIT

- this criteria measures the option's cost effectiveness in terms of benefits or energy efficiency realized.
- a ranking of five indicates that implementation of this option would produce a high degree of energy savings at little or no cost.
- a ranking of one indicates that the option would be very costly and any energy efficiencies realized would be minimal.

ENVIRONMENTAL CONSTRAINTS

- this criteria measures the environmental characteristics of the geographical origination of the option and includes such variables as topography, climate, demography, and overall urban character.
- a ranking of five indicates that the option was initially designed for an area very similar to Hamilton.
- a ranking of one indicates that the option was initially designed for an area which is very dissimilar to Hamilton.

DEGREE OF INNOVATION

- this criteria measures the degree of novelty or newness characteristics of the option, along with the associated degree of attitudinal and bureaucratic change and resistance required for implementation.
- a ranking of five indicates that the option is very traditional and therefore more easily adapted to status quo.
- a ranking of one indicates that the option is very innovative and implementation requires a high degree of change to processes and attitudes.

EXPERIENCE/RESULTS

- this criteria measures the experience and results of the option. Such variables as consumer acceptance, developer adoption, and municipal enforcement are monitored.
- a ranking of five indicates high quality positive results, and a ranking of one indicates extreme negative results.
- a ranking of three indicates that no experience has been recorded.

ANALYTICAL MATRIX

SIFT II

OPTION:

SIFT I
RANK:

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION						
	MODIFICATION						
	NEW CONTROLS						

ANALYTICAL MATRIX

The next step was to utilize the "basket" formulations and suggest improvements to existing City of Hamilton neighbourhood planning policies (page 122) and controls (page 155) to facilitate energy efficiency.

Generally speaking, those concepts which ended up in the collection "basket" revolved around two different and sometimes competing goals: energy conservation via superinsulation or passive solar collection. The objective of the former is to isolate the inside from the outside; the latter integrates building design and site planning to conserve energy. Combination of the two often provides the best results (page 51).

The results of the matrix indicate that many concepts have focussed on low cost methods involving little political or development risk to reduce energy consumption. The few comprehensive concepts that were identified show that most municipalities operate on a "monkey-see-monkey-do ad hoc" basis. Rarely do any of the concepts predict their potential energy savings. Rather it was assumed, erroneously at times, that the theoretical benefits would be realized and this was accepted as justification. This too is a reflection on the sophistication of energy planning.

The subjectivity of the evaluation process is recognized. The study team decided that this particular form of evaluation would produce the best results given the resource constraints. Although there are several reference sources chronicling energy conservation activities, few provide an evaluation and none have possessed the intent to implement. Had it been the purpose of the study team to design an objective analysis, the study costs incurred would have soared. For this reason, the design of the Analytical Matrix lends itself to computer adoption for objective analysis at a later date.

DISCUSSION

The following policies have been established to direct future development towards energy efficiency. Based on the preceding logic, the following policies are the result of an extensive review of national and international energy conservation initiatives. During our "scanning" the knowledge and efforts of others, one of the most striking observations was the amazing degree of multifarious concepts either touted or employed to conserve energy. All were placed in the Analytical Matrix; those energy planning concepts which successfully filtered through SIFT I and II evaluation have been formulated into manageable land use policies for Hamilton.

The scope of this study investigates the development of policies directed at energy efficient new neighbourhood planning. Although social, transportation, environmental, and other planning priorities comprised a basis, or a wholistic approach, through which the following energy policies were developed, they have been well developed in the past and need not be included here. While this study assumes that energy efficient land use planning must be given a higher priority in the planning process, it should not be placed on a pedestal precluding other planning priorities.

Land use planning, energy conservation, urban economics, and quality of life are all in a mutually supportive and complex relationship that demands a wholistic approach. For example: land use policies which increase densities by curbing urban sprawl reduce the need for extended municipal servicing, promote mass transit rather than automobiles, decrease space heating demands, preserve agricultural land, and reduce the amount of pollution created from the dissipation of energy.

Many energy efficient principles require the wholistic approach to facilitate integration with other planning priorities in order to be effective (e.g. solar access and street design). Design options taken singularly may be ineffective or have a low potential for conserving energy. The combination of such options through the wholistic approach will produce energy savings that are more significant. It should be emphasized that the development of new energy supplies or conservation measures cannot compensate for inefficient neighbourhood design.

Conversely, conflicts may also result between energy and other planning policies, e.g. the reduction of through traffic in neighbourhoods may conflict with the objective of conserving energy by reducing construction and trip length. The wholistic approach explains the beneficial or facilitating effect of energy planning on other land use objectives. The wholistic approach also provides for more informed decision-making, creates a broader platform of support for energy planning, and establishes policies and practices that can easily be expanded to include other conservation options at a later date. When a conflict is identified, a conscious decision is required on whether or not to forfeit energy efficiency.

The fact that there is no one change or adjustment that will produce massive energy savings should neither surprise nor disappoint us. The subdivision process, from design through approvals, construction, and sales, has been continually modified to serve society since its inception. Energy efficiency is but another modification in the evolution or maturation of this process (page 54).

By the City enacting policies addressing energy use in new neighbourhoods, it is providing residents and civic authorities with guidance on the planning measures incorporated into various forms of development to decrease energy consumption. These energy policies would serve to increase awareness of the need to conserve energy, and provide clear indication of the planning measures which should be implemented in neighbourhood developments to decrease the amount of energy consumed. Consumer and developer conditioning, or maturation, requires the stimulus of municipally adopted energy efficient land use planning policies.

The City has an opportunity to assist the development industry in designing more energy efficient neighbourhoods, rather than inhibiting the efforts of these organizations. As the cost of energy assumes a more prominant role, local development regulations must recognize this trend to ensure the economic well-being of the community.

The proposed policies are grouped according to:

- Site Selection;
- Land Use;
- Building Design;
- Transportation;
- Density;
- Development Standards; and
- General Municipal Action.

Each grouping is further divided into a brief discussion, objectives, and suggested policies.

SITE SELECTION

To maximize energy efficiency, it is necessary to develop a basic understanding of the site characteristics. The higher and ever increasing cost of energy requires analyzing the site problems and potentials in the beginning, as opposed to using energy intensive architectural and mechanical modifications to overcome mistakes in site selection and orientation.

From an energy efficient perspective there are advantages and disadvantages to any site. Proper site analysis of natural constraints ensures that the right land use activity will be placed in the right location. Modifications to the site should be minimized. The site development should be designed to enhance the liveability of the people and minimize energy consumption, without harming the site's ecology. The principles involved here are fully explored in PART TWO.

Every site analysis should consider the appropriateness of the land for the proposed development. For example, land often designated for urban construction may also be suitable for agriculture, natural resource recovery, or recreation. Urban expansion should be compact, contiguous, and directed towards land that will not increase direct and embodied energy costs that will be incurred by "farming" more marginal lands further from urban markets.

Climate, topography, and vegetation are the three major constraints in energy efficient site analysis.

Climate:

Each site possesses its own unique microclimate. Hamilton is fortunate in that detailed "Ecocharts" describing air temperature, sunshine, heating, cooling, precipitation, relative humidity, soil temperature, wind and shadows have already been prepared for the City and are further refined as a result of this study (Appendix "F"). This data may be readily adapted to individual sites by developers and planners to facilitate energy efficiency. For instance, a certain site may have few sunny periods, possibly precluding single-family detached housing with passive solar design and emphasizing superinsulated higher density development.

Topography:

Differences in slope are the main determinant of solar access. They also affect the site's vegetation pattern and microclimate. From greatest to least: south, flat, west, east, and north slopes receive varying degrees of solar radiation. East slopes heat up earlier in the morning and are cooler in the afternoon. West slopes stay cooler in the morning and are hotter in the afternoon. North slopes receive the least insolation while south and flat slopes receive the most because of their orientation. This suggests that structures utilizing solar energy be placed on south and flat slopes while land uses such as commercial or open space, which require less insolation, be located on slopes receiving less solar radiation (page 27).

Depressions may create fog zones or cold air pockets as cool air is more dense than warm air and sinks. Ridges and hilltops usually have a higher average wind velocity because they are above the zone of increased turbulence and decreased velocity created by trees and buildings. Sites whose main axis parallels the direction of wind flow can act to funnel the wind and increase velocities. Sites with the main axis perpendicular to wind flow can cause a downwash effect, decreasing velocities and increasing turbulence.

Life cycle costing may indicate that modifications to the topography, e.g. grading for south slopes, will provide substantial benefits in future years. The costs of energy-efficient planning and development must be measured against the savings of energy and enhancement of comfort over time.

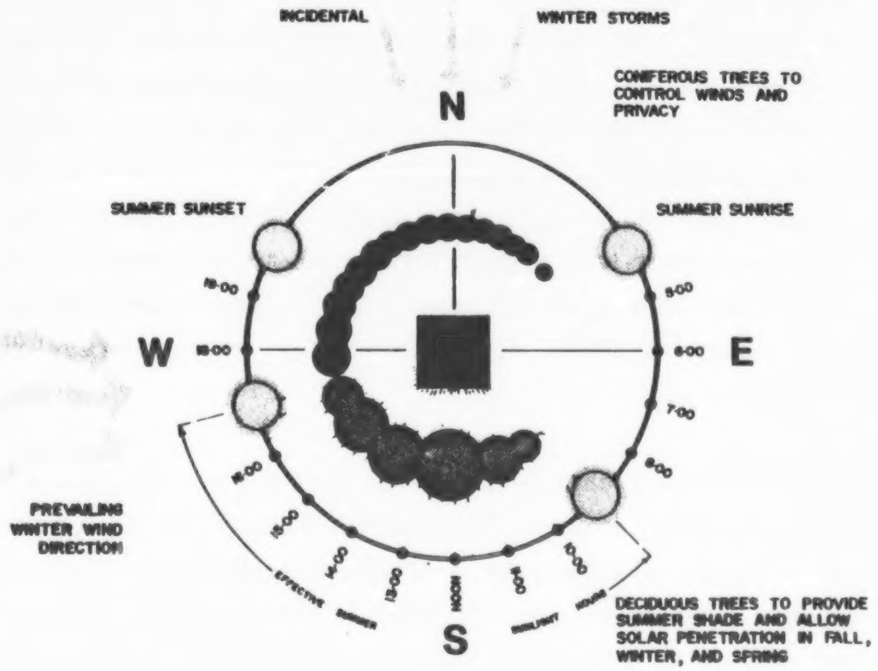
Vegetation:

Present technology and experience suggest that the most effective landscaping designs to increase a building's energy efficiency are achieved after construction. Although known to control wind, insolation, and snow patterns to increase energy efficiency, landscaping is extremely site specific and requires a tailored response for each building. At the planning stage, existing vegetation can sometimes be used to implement landscaping designs at great savings and quicker results than clearing a site and replanting.

Vegetation acts like an insulating blanket modifying temperature fluctuations. Plant cover cools the surrounding air by providing shade, absorbing radiation, and transpiring moisture for evaporation. Plants may be landscaped to increase or decrease wind velocities, directing winter winds away from and channelling summer breezes to buildings. Energy efficient planning finds the right balance between natural forces to implement warm summer cooling and cold season heating.

Objective

i) Analyze development site topography, microclimate, and vegetation to facilitate optimum energy efficient land use.


INCIDENTAL
WINTER STORMS
CONIFEROUS TREES TO CONTROL WINDS AND PRIVACY
N
SUMMER SUNSET
SUMMER SUNRISE
19:00
5:00
W
18:00
6:00
E
7:00
8:00
16:00
15:00
14:00
13:00
NOON
11:00
10:00
PREVAILING WINTER WIND DIRECTION
EFFECTIVE SUMMER DAYLIGHT HOURS
S
DECIDUOUS TREES TO PROVIDE SUMMER SHADE AND ALLOW SOLAR PENETRATION IN FALL, WINTER, AND SPRING

HAMILTON AREA

SOLAR LANDSCAPING

Suggested Policies

i) For approval of proposed neighbourhood development, require the submission of site plans which detail orientation and angles (steepness) of all slopes, i.e. Slope Orientation Synthesis.

ii) Do not squander the potential of flat areas or south slopes with proposed development not designed to utilize solar energy.

iii) For approval of proposed neighbourhood development, require that site plans have regard for monthly microclimate characteristics, namely: air quality, air temperature fluctuations, hours of sunshine, heating and cooling degree days, precipitation, wind speed/frequency/direction, i.e. Ecochart.

iv) For approval of proposed neighbourhood development, require the submission of site plans which detail existing vegetation, noting: location, species, height, and shadow patterns.

v) For approval of proposed neighbourhood development, require the submission of site plans which detail existing man-made features, noting: location, type, function, height, and shadow patterns.

vi) Ensure that a proposed development maximizes energy efficiency by minimizing the need for altering present site conditions.

vii) Develop a landscaping plan to guide the municipality's tree planting activities to increase the energy efficiency of existing and proposed land uses.

LAND USE

Mixed use development expedites the adoption of energy conservation measures and renewable energy technologies. As varied land uses are integrated, service and infrastructure networks, travel distances, and resource requirements are sizeably reduced. Any measure which reduces the average trip length, particularly work trips, will reduce energy consumption significantly. The efficiency involved with mixed land use is essentially to attempt to produce the best integration of mutually supporting land use activities (synergy).

There are many complex and nebulous variables that must work in concert to achieve mixed land use energy savings. It should be emphasized that our spatial separation between work and home environments is very strong. No one can ensure that habitants of mixed use development will actually shop or work in the development. Those developers who constantly register the cultural preferences of consumers know that many would find it undesirable to live in close proximity to their place of employment.

Assuming our cultural values of preferring segregated land uses change little in the near future, an interesting energy and socio-economic relationship presents itself. For instance, there is a definite trend towards downtown housing in mixed land use areas for those that can afford the high costs. Households of less affluence are shifting to the suburbs where their energy costs are higher, and where the only affordable housing is high density in mixed use areas that do not share the positive cultural values of downtown mixed use development. It is plausible that lower income households will end up bearing the brunt of energy conservation.

In general, municipal planners and the development industry share a basic cautiousness towards mixed use development. Development cost is directly proportionate to risk. The large amount of up-front financial resources required limits the number of companies which can become involved in the construction of mixed land use projects. Joint ventures are a solution but not desired, for there is a fear that if one of the partners falls there will be a bowling pin effect on the whole project. The relative unfamiliarity of mixed use development, together with the required changes and inherent delays to the mono use zoning of most neighbourhoods, increases risk. Although the embodied energy savings attributed to mixed land use are massive, this is of little significance to developers who are concerned with maximizing profits by minimizing costs.

Promoting mixed use neighbourhood developments to achieve energy efficiency is a long-term strategy that may not produce results for some time. Not unlike other land use plans, it takes time to determine the benefits and effects of energy efficient land use planning. It appears that in order to realize the optimum efficiencies of mixed land use planning, the practice must be applied to high density nodes, especially where existing infrastructure is in place to support such development, rather than to low density neighbourhood development (Maturation Zones, page 54).

Ideally, neighbourhood level mixed land uses should be placed in a location which is most accessible to motorists, pedestrians and cyclists. Smaller scale mixed land use development (e.g. five-storey apartment building with one floor commercial, office, institutional, or recreational) in new neighbourhoods will increase thermal efficiency and reduce the number and duration of automobile trips. Surface/volume ratio and distance association aspects of mixed use planning are discussed in PART TWO, page 40).

The energy savings of mixed use development will never be sold or successfully encouraged if its support lies solely on the goal of energy efficiency. The wider benefits of mixed land use planning should be compiled to build a base for the promotion of such development. As new neighbourhoods are built, it will become obvious which options lead to the greatest energy savings.

Objective

i) Encourage people to live in proximity to activity centres and particularly their place of employment through the development of multi-purpose land use centres as opposed to the scattered segregation of land use activities.

Suggested Policies

i) Promote, where complimentary, mixed land use developments through multi-purpose land use zoning, or through performance standards which facilitate mixed land use.

ii) Needless travel can be avoided if commercial (banks, restaurants, etc.) and public (parks, libraries, etc.) services are located within the immediate areas they serve.

iii) Locate community facilities such as schools, churches, libraries, recreational facilities, and other public buildings in multi-purpose structures within the areas they serve and not on the periphery of the development.

iv) Locate community facilities in new or existing nodes, on a transit line, and central to the population to be serviced.

v) Maintain a balance between the number of employment opportunities and households in various planning districts to decrease the length of journey-to-work trips and generally increase the energy efficiency of the transportation system.

vi) Relax zoning restrictions which currently prohibit businesses operated from the home if the operations do not generate pollutants or excessive traffic.

vii) Developments which will have a significant impact on the City's transportation and growth patterns should be located in developed areas presently served by established infrastructure networks.

viii) Incorporate the design of multiple use utility corridors and secure the co-operation of agencies having authority in this matter.

ix) Combine transportation routes with utility corridors.

x) Design utility corridors as open space for recreation and as access to open space and recreational opportunities.

xi) Design open space areas, e.g. parks, utility corridors, graveyards, etc., as buffer areas controlling shade and wind.

xii) Establish "maturation" policies and zones to provide for the future accommodation of new and additional land use activities.

BUILDING DESIGN

Energy efficient subdivision and building design maximizes natural on-site features to reduce heating, cooling, lighting, landscaping, and servicing costs. The energy efficient design of new neighbourhoods is the lowest cost, easiest, and most marketable alternative in decreasing non-renewable energy consumption. The implementation of energy efficient design will invoke a minimal degree of consumer resistance because it is not a radical approach but merely a refinement of existing neighbourhood planning.

The precise principles of the passive solar approach have been developed in PART TWO. For the purposes of this section, energy efficient policy formulation for building design is based on the premise that any building with its longest axis oriented east-west will gain the minimum amount of heating during the summer and receive the maximum during the winter. Unobstructed solar access and the proper orientation of the building, together with the sensitive placement of doors, windows, and thermal mass, result in substantially lower energy costs for the life of the structure.

Objectives

i) The optimum sun and wind orientation of all buildings in the design of new neighbourhoods;

ii) The design and location of building fenestration to maximize the use of passive solar gain;

iii) South wall solar access throughout the year between 09:00 and 15:00 hours for all buildings;

iv) The development of buildings incorporating energy efficient elements such as super insulation, atrium, or earth sheltered design; and

v) The use of appropriately selected and located vegetation that will reduce the energy consumption of buildings.

Suggested Policies

i) For approval of proposed neighbourhood development, require conformance to the proposed Energy Use Assessment (page 164).

ii) For approval of proposed neighbourhood development, require the submission of site plans which detail, in addition to existing requirements: lot, street, and building orientation; landscaping, placement and type of vegetation; shadow patterns; solar access; wind flows; and snow drifting.

iii) In selected areas (maturation zones, page 54), remove height, yard projection, front, side, and rear yard zoning restrictions. Adopt Solar Envelopes in their place. Solar Envelopes facilitate energy efficiency as well as maintain the reason d'etre for the previous restrictions.

iv) In areas where Solar Envelopes are deemed inappropriate:

- design lots that are wider and shallower, elongated in an east-west direction, maintaining the total lot area and useable open space, but increasing southern exposure;

- set uniform rear yard setbacks for north entry units and uniform front yard setbacks for units with a south entry;

- provide wide sideyards on north-south streets to avoid shadowing problems between adjacent buildings;

- allow for slightly greater frontage on north-south streets to permit sun penetration into second storey windows and to minimize the blockage of sun on the south face by garages.

v) Develop proposed buildings to maximize energy efficiency by minimizing the need for altering present site conditions.

vi) Require all new draft plans of proposed subdivision to be designed with regard for the energy efficient guidelines contained in PATH I or PATH II. Council should direct the Planning and Development Committee to consider energy efficiency when reviewing plans.

vii) Ensure that all developments which are subject to site plan approval agreements will not mitigate the potential passive solar energy gain of land uses within, or in close proximity to, the proposed development.

viii) Encourage the Regional Municipality of Hamilton-Wentworth to allow its approved draft plans of subdivision to lapse if the plan has not been registered within three years of receiving draft approval; or, if the subdivider indicates a preparedness to redesign the draft plan with regard for Council's energy efficient design criteria, then extend draft approval for periods of one year until registration of the redesigned plan.

TRANSPORTATION

At the neighbourhood scale, common sense dictates that energy efficient transportation system planning involves the logical integration of land uses to lessen the need, distance, and number of trips. As land use planning controls densities, transportation system design, land use arrangement, etc., one can assume that energy efficiency in transportation can be achieved through planning (distance associations, page 57). Indeed, a great deal of theoretical research supports this assumption.

To effectively reduce transportation energy demand at the neighbourhood level requires land use design which influences trip generation, distribution, distance, and mode of travel. This would entail broad changes to our cultural values that will likely not be realized in the lifespan of this study. Planning can promote or encourage such changes and facilitate their eventual adoption, but it will not determine energy efficiency.

It is widely believed that the private automobile will continue to be the primary mode of travel for inter-neighbourhood tranportation. Present and foreseeable market preferences for single family detached housing in segregated neighbourhoods often preclude the cost-effective use of public transit. The provision of public transit by itself is not enough to change behaviour and its facilitation in areas where it will be under-utilized is energy inefficient.

Improved effectiveness of the street network can be achieved through traffic control, roadway improvements, and the promotion of non-traffic related programmes such as variable hours to spread out peak hour traffic flows in areas of concentrated development.

Narrower and straighter local streets will reduce construction material requirements and driving time. The number of streets connected to the larger city street network should be kept low to reduce through traffic in the residential areas. Both sides of streets should be developed to maximize use of the street. Walking and bicycling should be promoted as the primary means of travel for intra-neighbourhood transportation.

Objective

i) Maximize energy conservation by reducing consumption of conventional fuels, improving travel efficiency, and promoting the substitution of alternate fuel sources.

Suggested Policies

It is estimated that 50 per cent of all direct energy used by a single family household is attributable to the use of the private automobile.

Internal neighbourhood design elements to achieve energy efficiency in transportation include:

i) Encourage the agencies involved to maximize public transit use by the neighbourhood through the provision of bus shelters, route map displays, benches, and paved waiting areas.

ii) Encourage major employers to provide employee transit passes and secure employee bicycle stations in lieu of free parking.

iii) Promote a mix of land uses, multi-purpose centres, and compact design to encourage intra-neighbourhood walking and bicycling.

iv) Require the provision of a walkway/bikeway system which connects with a continuous community system to facilitate convenient safe access to local commercial, institutional, recreational, and public transit; and encourages inter-neighbourhood walking, bicycling, cross-country skiing, etc.

v) Minimize existing four-way stop intersections on local roads and limit all new four-way stop intersections on collector roads to those intersections where such signs are necessary to facilitate the orderly flow of traffic.

vi) Promote the development of controlled access highways and limited access arterial and collector roads to increase the efficiency of inter-neighbourhood traffic circulation.

vii) Install road sensors at all traffic lights; minimize total length of street network; avoid dead ends.

viii) Orient higher density residential and major employment developments toward arterial roadways and public transit junctions, thereby increasing the convenience and reducing travel distances for the maximum number of people.

ix) Continue to improve the effectiveness of existing and future roads so as to minimize unnecessary energy consumption, i.e. reduce the number of intersections, maintain quality road conditions, etc.

x) Encourage a system of staggered work hours for major employment concentrations to reduce traffic congestion, e.g. flex hours, part-time employment, homework via telecommunications, etc.

xi) Encourage the appropriate agencies to permit the distribution of propane and compressed natural gas at service stations.

x) Facilitate efficient transit service by arterial or collector street plan rather than a curvilinear street design.

DENSITY

The potential for energy efficiency in new neighbourhoods is greatest when development is compact and contiguous. Such an urban form reduces the distances between various land uses, reduces the amount of energy required to heat and cool individual building units, and facilitates the more intensive use of land and infrastructure.

An overall increase in the density of development means not developing the sprawling suburbs that have been the norm since 1950. Due to the common walls and smaller surface area to volume ratio, higher density development offers lower space heating and cooling demands. Increased densities facilitate mixed land use as a wider range of land uses can be supported in a closer proximity to residences. Increased densities also provide for the more intensive use of public transit, and generally reduce per capita transportation costs.

Maturation or growth of an urban area is best accommodated by infilling and redevelopment of already serviced land (pages 54 to 57). Urban sprawl, as a form of expansion, is decidedly energy inefficient. The polycentric urban pattern appears to be more energy efficient than linear or concentric land use arrangements, mainly because it decreases traffic congestion, thus increasing vehicle fuel use efficiency.

The energy conserver society pushed by senior levels of government is in constant collision with our cultural momentum. Energy efficient strategies requiring changes, at this time, to cultural values will have only minimal success. For instance, increasing neighbourhood densities could meet stiff resistance as there are strong values placed on the space, location, privacy, status, etc. characteristics of detached housing. Perception of such values and expectations cannot be ignored or changed quickly.

A sub-optimal or conditioning strategy to achieve energy efficiency through increased densities is to promote the "cluster housing" concept. This is one of the most energy efficient building configurations as it reduces the length of road, sewer, water, and electrical networks, while still providing the amenities desired in neighbourhood development at densities of 50 to 75 units per hectare.

An alternative sub-optimal strategy would be house sharing. Although generally prohibited by neighbourhood zoning, house sharing is spreading among persons not having the necessary resources for, but desiring the amenities of, single family detached development. Policies promoting house sharing would attract young adults entering the home buying cycle and, for elderly persons, would provide a housing solution superior to that offered by our present institutions.

Objectives

i) Provide for the development of well-designed increased densities for all land use categories;

ii) Promote the development of increased densities with mixed land uses along transportation corridors; and

iii) Promote the development of small parcels of vacant land or under-utilized land within urban areas; ensure that areas designated for new neighbourhood development are in close proximity to existing developed areas.

iv) Require the planning and development of Maturation Zones within specific areas of neighbourhoods.

Suggested Policies

i) Increase neighbourhood densities by promoting development of low-rise, medium, and high-density housing;

ii) Encourage "cluster" and "zero lot line" developments;

iii) Reduce residential lot size requirement where appropriate;

iv) Reduce lot frontages where possible;

v) Ensure that all local roads have lots on both sides;

vi) Orient increased density developments toward arterial roadways and public transit junctions;

vii) Permit the development of homes that may be easily partitioned to create a semi-attached unit at a later date; and

viii) Plan for Maturation Zones (page 54) by allowing for increased densities in the future while developing for current market values by designing large lots which may be subdivided to facilitate infilling at a later date.

ix) Relax zoning restrictions to permit house sharing in specific areas.

DEVELOPMEMT STANDARDS

Significant energy and development costs can be saved by modifying antiquated development standards. The subject of reducing municipal development standards has already been thoroughly investigated in much greater detail than what is presented here. Yet outdated development standards continue to exist out of convention, reluctance to change, and ignorance of improved design technologies. Just as energy efficiency does not entail energy sacrifice, reduced development standards do not mean reduced development quality.

Modified design standards for roadway facilities in residential areas, for example, can lead to significant cost reductions in housing as well as requiring fewer materials, less maintenance, and contributing to more energy conserving development. This can be achieved while at the same time maintaining standards which adequately provide for the health and safety of residents. Modified standards for capital works in a neighbourhood, combined with increased densities, can also reduce the rate of increase in housing costs that might be associated with other energy conserving measures such as increased insulation, air tightness, glazing, etc.

Development standards are an element of energy efficient land use planning. The following policies represent easily implemented strategies which produce immediate benefits and encourage the use of energy efficiency to reduce energy utilization and costs.

Objective

i) Increase the cost effectiveness and energy efficiency of new neighbourhood development by modifying inappropriate development standards.

Suggested Policies

i) Encourage the adoption of the following cost saving innovations to be applied to the design of storm drainage system for new low density neighbourhood development:

- permit roof downspouts to discharge at ground service;

- allow foundation drains to connect to sanitary sewer;

- realize that, to maintain present standards, it is not necessary for storm sewers to individually service each building; and

- permit the use of drainage swales and shallow detention ponds to control storm water runoff.

ii) During the initial hook-up of sewer and water lines to single family attached units, permit the use of double service connections where appropriate.

iii) Promote the design of streets which minimizes grading quantities, designs with topography, avoids excessive runoff, and minimizes the need for storm sewers.

iv) To reduce pumping, discourage construction in high areas or in areas far from source of fresh water or sewage treatment.

v) Modify sidewalk development standards to actual needs, e.g. sidewalks on local roads may be unnecessary if a linear park/pathway is provided.

vi) Provide flexibility to allow on-site waste disposal systems.

vii) Modify pavement widths on local roads to eight metres, and to seven metres on minor local roads in new neighbourhoods developments; or as recommended in Ministry of Municipal Affairs and Housing publication, "Urban Design Standards".

viii) Modify right-of-ways on local roads in new neighbourhood developments from 20 metres to 17 metres on the condition that solar access is maintained for the greatest number of buildings possible.

ix) Increase the distance between street lighting fixtures and use high efficiency sodium lamps for street lighting.

x) Keep municipally owned lawn areas to a minimum. Select low maintenance climate adapted vegetation (e.g. along median strips) and maintain open space dedications in their natural setting.

xi) Relate parking requirements to actual needs, consider revisions to requirements if supported by analysis, or conforms to C.M.H.C. "Parking Area Advisory Document".

xii) Encourage regulatory agencies to be receptive to innovative design ideas.

GENERAL MUNICIPAL ACTION

There are a number of strategies that do not fall under the preceding categories that may be used to reap the benefits of energy efficiency. Hamilton can indirectly control the energy efficiency of neighbourhood development through the issuance of building permits, the planning of public facilities and services, transportation and utility phasing, major expenditures in the public sector, economy and taxation.

The following list describes general strategies that a municipality can employ to increase the energy efficiency of new neighbourhood development.

i) Actively pursue federal and provincial funds to develop, maintain, and expand energy conservation programs and demonstration projects in order to gain the most in experience, benefits and recognition.

ii) Amend the property standards by-law to require buildings to have a reasonably efficient furnace; performance standards may be adopted from the CMHC.

iii) Require a life cycle costing analysis as part of the approval process for all proposed municipal expenditures related to development.

iv) Promote the development of waste recycling programmes; the disposal of wastes should permit the recycling of materials and the capture of energy from non-recyclable materials (e.g. incineration (SWARU), landfill gas production, or community facilities for composting).

v) Promote the use of locally produced energy, foodstuffs, construction materials, labour, etc. to reduce transportation costs (e.g. provide land for collective gardening plots in open space areas; give priority to local tender bids; or relax restrictions against compatible animal raising in urban areas.

vi) Initiate a study to investigate department programmes and procedures which act as barriers to energy efficient land use planning; suggest incentives for adoption of energy efficient policies and strategies; staff training and development; and the assignment of responsibility and accountability for analysing the energy efficiency of development proposals.

vii) Initiate a study to determine the advantages and disadvantages of managed urban woodlots on public and private open spaces.

viii) Co-operate with Hamilton Region Conservation Authority and the Ministry of Natural Resources to provide regional and city parks within or in close proximity to the City to discourage long distance trips for short term recreational purposes.

ix) Encourage local financial institutions to provide mortgages for energy efficient homes below the market rate and/or requiring a decreased down payment.

x) Establish an information service/conditioning campaign directed at developers, builders, and residents to essentially promote the policies, strategies, and principles involved in Energy Efficient Design.

xi) Sponsor neighbourhood seminars, or outreach programs, to explain to existing and prospective residents of energy efficient development the energy saving features of their homes, demonstrate the economic advantages, and suggest behavioural changes for even greater energy savings.

xii) Encourage the use of energy audits to determine the manner in which the efficiency of land uses can be upgraded.

DISCUSSION

An obvious result of the misnomer "energy crisis" has been an increased awareness of the need to conserve energy. Yet the real implications of energy conservation are still not widely understood. Many people feel that incentives and programs for energy conservation will only increase unemployment, halt economic growth, and generally put the brakes on "progress". One can see that the concerns of inertia change little, for these are the same arguments used against the adoption of environmental planning in the seventies and social planning before that.

Actually, the emergence of energy planning is not a cause of, but a consequence of, a poor economy. Profits must now be "squeezed", with greater emphasis placed on the significant cost benefits of energy conservation. We are now being re-taught or reconditioned to the economics of saving energy. What may seem like unpopular changes now will, in fact, become desirable in the near future. These changes riddled the research and preparation for this report. A few are highlighted here as new directions for planning.

WIND CONTROL FOR NEIGHBOURHOOD PLANNING

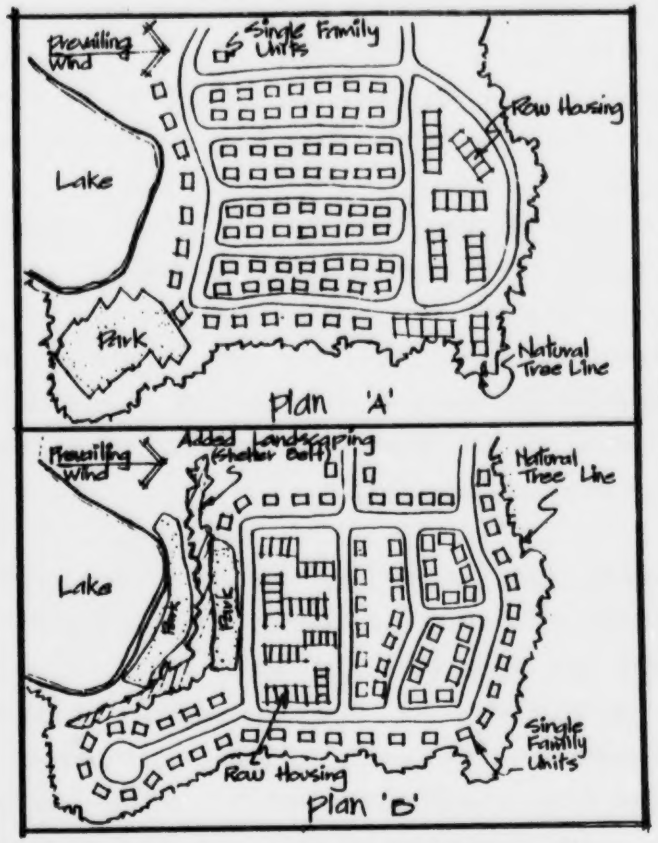
The design of energy efficient housing units extends beyond construction details such as insulation and vapour barriers. Designing to reduce energy consumption in the early planning stages by including the effects of the microclimate (wind, snow, sun) has only recently become a consideration. Although all aspects of the microclimate are important, the wind has one of the greatest impacts on energy loss. Research has been done to determine the actual energy consumption due to wind infiltration but little is known about approaching the problem at the planning level.

Planning guidelines would enable designers to rationally assess their designs on the basis of wind control. However, before these guidelines could be developed, there are a number of questions that have to be answered. First, what are the effects of street layout, house size, house spacing and house height on wind speed as well as the natural sheltering capabilities of landscaping and terrain. For example, which of the following two subdivision plans would provide the most overall shelter from the wind. Plan "B" is best suited as it makes use of landscaping (both natural and added) and larger row housing units to protect the single family units. In addition, the street layout opposes the prevailing winds, therefore dissipating the wind.

Although Plan "B" is best suited, there are still questions that should be answered, such as:

(1) What is the basis for the above judgements?
(2) How do you convey this knowledge to planners?
(3) What is the probable wind environment around "B"?

Research would help answer these questions. Compiling data on wind speeds around typical residential layouts could be the basis for the wind guidelines. To approach the problem with field measurements would not only be time and labour intensive, the residential configurations available for study would be very limited. Research of this nature is much more adaptable to the laboratory where wind velocities around scale models could be quickly recorded utilizing a wind tunnel. Numerous residential layouts could therefore be examined within a short period of time. The information gathered during these tests could be compiled into qualitative design criteria that would illustrate the fundamentals of wind control, thus enabling designers to reduce wind infiltration and related energy losses at the planning level.


Prevailing Wind
Single Family Units
Row Housing
Lake
Park
Natural Tree Line
Plan 'A'
Prevailing Wind
Added Landscaping (Shelter Belt)
Natural Tree Line
Lake
Park
Park
Single Family Units
Row Housing
Plan 'B'

Courtesy of Williams, Morrison, Hershfield, Theakston, and Rowan Limited

C.A.D. PLANNING (COMPUTER ASSISTED DESIGN)

The age of computers, expounded by futurists for decades, has become an expanding necessity for municipal operations and possesses massive implications for land use planning. For instance, in contrast to the high amount of energy required for transportation of goods and people, only a relatively low amount of energy is required to convey information. While transportation costs are soaring, the cost of telecommunication is shrinking. When the cost of installing and operating telecommunication equipment falls below the cost of transportation, employees may work in their homes or in dispersed neighbourhood work centres. This may remove a great deal of the downtown's domination or centralizing effect on neighbourhoods.

Computers are presently designing subdivisions and buildings according to strict energy budgets. These designs are acceptable for legal registration and more than appropriate for the day-to-day requirements of government, developers, and consumers. Major consideration should be given to initiating a tangent study which investigates this report's suitability for computer application. For the purposes of energy efficient land use planning, this technological combination can easily: compute the geometry of shadow patterns or solar space envelopes, evaluate the terrain as a solar collector, design the most efficient transportation and service systems, assign optimum orientation for each structure, plan for the maximum number of dwellings, design the landscaping to conserve energy, and much more.

HOME OCCUPATION

Hamilton has regulations and Official Plan policies addressing the conversion of existing residential units for the purpose of prohibiting home occupations. Most recently, an application for a one chair hair salon as an accessory use in a single family detached home met considerable resistance. In light of the fact that many municipalities are facilitating mixed land use of this nature, the objective of segregating land uses must be reexamined. When viewed from an energy conservation perspective, the promotion of home occupations serves to decrease the demand for energy by:

i) decreasing the extent of transportation energy a homeowner will use to travel from the location of employment to the site of the homeowner's residence by eliminating the journey-to-work trip;

ii) decrease the extent of energy necessary to heat and cool the space required to conduct the business.

MARKETING

Energy efficient development is presently situated in the adoption stage where demand is low and risks are perceived as high. During this stage, the major prerequisite for competitive success is a sound marketing strategy. A logical tangent of this report would be a review of marketing experiences dealing with energy efficient development. The goal of this project would be the identification of marketing problems and the formulation of municipal policies and strategies to promote energy efficient development (page 155).

Part Five

Land Use Control

DISCUSSION

The adoption and implementation of land use controls to ensure energy efficient development are a municipal responsibility. Given the economically conservative era that we are heading into, energy planning should be introduced in phases and the results be monitored so as to gradually increase the support for energy efficient land use planning.

Land use regulations reflect community sentiment and do little to force a change in behaviour. Past experience with environmental planning teaches us that it will take years for society to accept and adopt the development controls necessary to optimize energy efficiency. The importance of public education in this matter cannot be overstated.

Energy efficient neighbourhood development is largely dependent on developer decisions determining type, form, location, materials and methods used in construction. As described on page 15, neighbourhood development that was once closely related to the surrounding environment is now actually designed for energy consumption because the cost of energy was not considered a design determinant. Aside from the huge energy demand for heating, cooling, and transportation, development affects energy use indirectly by altering the demand for goods and services. For example, different dwelling types create different physical space demands for appliances, furnishings, and other accoutrements. Similarly, energy planning can modify demand for automobiles, asphalt, garages, heating and air conditioning, elevators, etc.

Interestingly enough, by increasing energy conservation we potentially decrease energy costs and increase disposable income. This income may then be used to purchase goods and services that are more energy intensive than what was originally saved. In other words, the re-spending effects of what is saved may increase energy consumption, but boost the local economy. As with all decisions, there are trade-offs to be made. The absence of a monitoring scheme further complicates energy decisions as the impact of trade-offs can only be guesstimated.

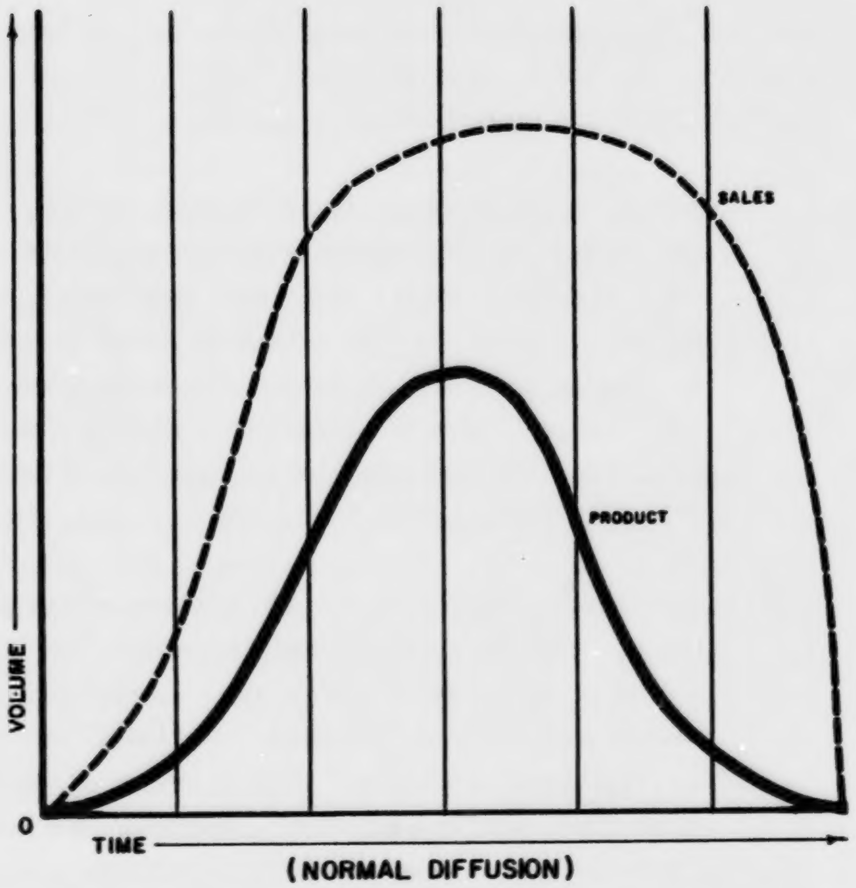
The major roadblock to widespread adoption of energy efficient development is cost. While it is unquestionably true that the life-cycle cost of energy efficiency is competitive, the higher front end costs act as a barrier to adoption. Ideally, widespread adoption could occur overnight simply and justifiably, by increasing the various taxes and levies on energy inefficient development while rewarding energy efficient development with an appropriate decrease. However, such a strategy would require legislative changes that are not forthcoming.

Numerous studies (reference 100) indicate that the Federal and Provincial governments have successfully instilled a very favourable public attitude towards energy efficiency. Operating costs are now widely considered by financiers and builders in the development process. New home buyers are increasingly prepared to pay the additional costs for energy efficiency (reference 44). However, too few developers are prepared to incorporate energy saving features that increase building prices and developer risk.

To date, some developers have incorporated energy saving features in order to make their projects more fashionable or appealing to a contemporary clientele. In isolated cases this has led to concerted energy conservation efforts; but mostly it's a marketing gimmick similar to other design hypes such as row housing with colonial columns, simulated wood or brick siding, and tudor facades on buildings that are anything but tudor. This is simply a poor marketing strategy, for the life cycle curve of energy efficient housing is not yet at the stage where such hypes succeed. Energy efficiency is not yet fashionable; it is definitely a deeply rooted trend, but to become a hype its consumer attraction or desirability must become greater. This desirability can be attained by marketing the product through emulation of affluence.

A municipality can influence such a marketing strategy in a number of ways. For instance, it can encourage up to the point of requiring passive solar assisted heating in single family detached housing on large lots. Passive solar becomes associated with the values we place on large lots and expensive homes. Although less politically attractive than other strategies, it is very effective, easily implemented at low cost, and a valuable conditioning measure.

Homes will not be developed or sold for energy conservation reasons alone. Energy efficiency must be



PRODUCT LIFE CYCLE CURVE

SOURCE: TAYLOR, MILLS, LONG RANGE PLANNING FOR MARKETING AND DIVERSIFICATIONS, 1971

marketed along with home features of perceived affluence such as circular staircases, and the benefits in cost savings must be communicated to the homebuyer. Given the present and near future life cycle curve, it should be realized that consumers will opt for attractive features such as attached sunspaces before an air vapour barrier which cannot be seen. Besides their conservation benefits, the many other functions and values of energy saving features must be recognized by the developer and conveyed to the consumer.

Marketing is shifting away from wastemaker concepts of planned consumption and obsolescence towards a new emphasis on value and longer life. Clearly, the development industry possesses an outdated marketing strategy which has lagged behind and is now in conflict with the technological and cultural advances of energy conservation. The municipality can help modify this strategy by removing barriers, offering incentives, and including energy efficient criteria in development control.

It should be recognized that the legal avenues by which a municipality can require changes in development design to increase energy efficiency are limited; and it is unlikely that the Province will introduce legislation to alter this fact. Therefore, existing municipal powers must be used to reap the benefits of energy efficient land use planning. Hamilton should influence development through control strategies supported by Official Plan policies.

PHASING

Policies were formulated and designed to be implemented according to their phasing (page 118). Phasing is divided into three categories:

i) The first category is to deregulate, remove, or amend existing development regulations, controls, and policies which act as impediments or barriers. This is the simplest phase and is subject to the least resistance. The adoption of this phase offers immediate results while providing a necessary basis and conditioning effect on which latter phases are dependent.

ii) The second category is to adopt those strategies having the greatest immediate effect on the energy efficiency of new neighbourhood development without imposing relatively radical or additional controls. The majority of these strategies modify existing processes and are incentive rather than mandatory in nature.

iii) The third and most stringent phase is to mandate the energy efficiency of neighbourhood development in order to obtain approval.

Phasing is a necessary conditioning approach for all parties involved. To immediately commence with high profile strategies would only create conflicts and misunderstanding which would postpone the benefits of energy planning. It takes a considerable amount of time and effort to change existing systems. It takes even more time and effort to implement new controls.

Those strategies which fall into the deregulation and modification categories generally contain a mix of voluntary and incentive measures. More importantly, they are relatively easy and visible but innocuous strategies that provide results without serious conflict and condition those involved for future regulatory measures.

While the third category offers the potential for optimal energy savings, it also represents solutions which often possess the greatest resistance to adoption. In general, the deregulation and modification categories possess solutions which offer less resistance to adoption with sub-optimal results.

For example, a mandatory increase in residential densities can result in energy savings. However, developer resistance to increased regulation, together with consumer dislike of high densities in a new neighbourhood setting, suggest that the energy benefits of such a strategy will never be realized. Alternate solutions of reduced lot size, clustered development, or zero lot lines moderately increase densities and provide sub-optimal energy savings without increased regulation. Thus, deregulation and modification strategies are the major thrust of this report and favoured over new controls.

DISCUSSION

The primary measures for requiring conformance to energy efficient planning policies are the land use controls provided in the Planning Act. This Act delegates specific powers to the municipality to control development; in particular: zoning, site plan control, subdivision agreements, and plans of subdivision. Without causing major changes to the planning process, these controls may be altered to facilitate energy conscious planning.

The actual implementation of policies through controls is slated for Stages Two and Three of this study. However, a brief discussion on a recommended implementatation process is provided in this section.

ZONING

Zoning in Hamilton is prescriptive rather than performance oriented. For the purposes of this study, the prescriptive approach creates regulations which are relatively inflexible as far as accommodating new technology or design. For instance, greenhouses or attached sun spaces may not be permitted in certain zones because they may contravene set-back regulations or exceed the maximum amount of floor area permitted in a lot. Conservation measures such as this can improve the energy efficiency of buildings, are not detrimental to the comfort, enjoyment and safety of residents, yet may contravene a municipal by-law.

The majority of zoning conflicts with energy efficiency deal with density, mixed land use, street, lot and building orientation, building height, yard set-back restrictions, and development standards. The latter are essentially minimum standards to be fulfilled by the development. Although many Canadian municipalities are considering or have already undertaken measures to encourage increased energy efficiency, few have attempted to achieve results through zoning. Essentially, a municipality may remove or modify provisions through amendments or variances to the zoning by-law.

The amendment approach generally requires greater study and is more comprehensive. This approach has the potential to remove a number of barriers at one time, exhibits municipal confidence and leadership in energy conservation, and facilitates the adoption of energy efficiency by removing the necessity of obtaining a variance.

As part of an overall review to update its zoning by-law, the City of Woodstock, with a grant from the provincial government, amended zoning regulations to ensure maximum energy efficiency in land development. Although a number of small changes were eventually made to increase the flexibility of zoning by-laws for energy efficiency, the irregularities of site specific implementation made it inappropriate to apply "blanket" provisions that would be effective and not too restrictive.

The Hamilton Zoning By-law is a voluminous document. To perform a study similar to Woodstock's would be a monumental task beyond the resources of this project. The cost of such a review dictates that it should be performed in conjunction with a total zoning by-law update.

In comparison, the variance approach has been used by a number of municipalities on a case-by-case basis to resolve conflicts by simply exempting alternate energy systems or energy conservation measures and their related components from zoning provisions. Of the municipalities studied, this approach was employed more frequently because it allows the municipality to proceed on a limited basis until energy efficiency develops greater support and sophistication. Resolving conflicts through variances is likely to provide quicker results, and cost much less than the comprehensive effort required to evaluate amendments. However, variances may incorrectly evaluate the conflict and grant exemptions that create even greater problems.

Variances and amendments can certainly be combined. Alternatively, the adoption of Energy Efficient Performance Standards (PATH II, page 169), would eliminate the necessity of variances or amendments since all energy conservation measures are permitted providing the "standards" are satisfied.

A major proposal of this study is the adoption of Solar Envelopes in selected neighbourhood development areas. The passive solar emphasis of this study depends on the assurance of solar access. The solar orientation of the building or structure is a relatively simple measure requiring deregulation or modificiation of existing zoning controls. The proposed Solar Envelopes are essentially building envelopes which are common planning tools familiar to the development industry, municipal administrators, and similar to conventional zoning. As the envelopes are quantified in terms of dimension and angle, they can be set in by-law form under Section 35 of the Planning Act. The purpose is to ensure maximum solar exposure to the greatest number of buildings or structures in the affected area.

Landscaping to control wind and snow patterns is an effective measure to increase energy efficiency, but is extremely site specific and requires a tailored response for each building. Hence, no prescribed land use control is capable of regulating landscaping to increase energy efficiency. Once again, the performance standard approach of PATH II proves more desirable in terms of design, implementation, and regulation. An appropriate property standard by-law may be required to control planting and maintenance of landscaping after development.

SITE PLAN CONTROL

Where there is an Official Plan in effect, Council may pass a by-law requiring a prospective developer to submit a site plan with his application and to enter into an agreement with the municipality regarding on-site features of the development, such as conceptual design, road widenings, access, parking, walkways, floodlighting, and landscaping, among others.

The by-law may require not only the provision of facilities but also their future maintenance. This authority permits the municipality to require energy efficiency in design, construction and operation. Any agreement between the municipality and the developer may be registered against the land so that it will bind subsequent owners. For instance, restrictive convenants imposed by a developer, as agreed upon by him with the municipality, currently control location of structures, height, landscaping, shading, etc. The municipality is often required to enforce the provisions of such an agreement.

In Hamilton, the site plan control by-law presently applies to specific zoning areas. Appendix "D" lists a number of energy planning measures which, together with the principles discussed earlier (PART TWO), may be required through site plan control. In certain circumstances, it may be desirable to allocate parcels of land within plans of proposed subdivision, subject to site plan approval, giving the municipality added control.

SUBDIVISION AGREEMENTS

The limitations of municipal zoning powers provided the impetus for the amendment of the Planning Act to include additional development criteria to be satisfied through binding agreements. The City of Hamilton has incorporated zoning by-laws and development control agreements into the municipal planning process. In particular, the City has decreed that any development or redevelopment in specific areas will be subject to both zoning restrictions and the terms of a development control agreement.

The municipality can regulate only those aspects of development set forth in the Planning Act or other relevant legislation such as the Municipal Act. The dubious wording of such legislation, as it pertains to subdivision agreements, is open to interpretation and offers municipalities the potential to require energy efficient building design as a condition of subdivision approval.

In Hamilton, this strategy poses difficulties in that the present terms of reference for Subdivision Agreements would have to be expanded to include building design. The Ministry of Municipal Affairs and Housing's policy on this matter is that design controls by the municipality are value judgements and would not be supported by the province if contested. Nevertheless, several municipalities are successfully applying such controls to achieve energy efficiencies in neighbourhood development. If the City decides to adopt this strategy, all or part of Energy Efficient Design Criteria Checklist (Appendix "D") may be included as conditions of development in a subdivision agreement.

PLAN OF SUBDIVISION

Essentially, a plan of subdivision is a proposal that a developer is required to submit to the municipality, detailing, among other things: size of lots and their layout; total number, type and density; the street plan; topography; and services available or to be provided.

Several Ontario municipalities documented in Appendix "C" are considering or currently requiring energy criteria in the submission of draft plan of subdivision. Presently, Bill 159, an Act to Revise the Planning Act, Section 51, states:

> (4) In considering a draft plan of subdivision, regard shall be had to
>
> (xii) the physical layout of the plan having regard to energy conservation.

Plans of subdivision can easily be designed at little or no cost to include such energy efficient principles as solar orientation, solar access, or micro climate sensitive landscaping. Design features, such as those listed in Appendix "D" (Energy Efficient Design Criteria Checklist), can be included in subdivision agreements as conditions of plan of subdivision approval. Planners should review submitted plans of subdivision to demonstrate to developers how energy efficient features may be incorporated into their plans without economic loss.

DISCUSSION

One of the key elements in formulating and implementing energy efficient land use planning is a monitoring program. Such a program is used to identify levels and patterns of energy consumption and measure the effectiveness over a geographical area.

A comprehensive program would monitor all forms of energy used and gather data necessary to evaluate the implications of energy efficient policies and strategies while pinpointing additional opportunities. Conversely, the lack of a monitoring program is a serious barrier in assessing the effectiveness of energy policies and strategies. The design of a comprehensive monitoring program is a monumental task. The City is presently working towards this goal under the Community Energy Management Program.

To determine the energy efficiency of a proposed development during the development approval process, relevant information should be requested from the owner proposing to develop that particular property. Such information would serve to identify the potential impact of the proposed development on the municipality in terms of energy demand. Further, the review of such information could also provide some insights into possible energy savings which may be available if the project were constructed in accordance with the Energy Efficient Design Criteria Checklist (Appendix "D").

A fundamental strategy of this study, which also has direct bearing on the current monitoring program, is the adoption and enforcement of a proposed "Energy Use Assessment By-law" to promote energy efficient new neighbourhood development. Obviously, this strategy is an exception to the study team's desire not to increase regulation. However, this strategy is badly required if we are ever to get a handle on energy conservation, for developers and consumers must become more responsible for the energy consumption of their buildings. Principal opposition to this by-law will argue that the free market will force the implementation of energy efficient development. The study team essentially agrees with this but feels a gentle "push" is needed to hasten adoption.

A Proposed Energy Use Assessment Draft By-law:*

1. In this by-law, "development" is defined as the construction, erection, or placing of one or more buildings or structures on land.

2. In this by-law, "neighbourhood" is defined as a recognized planning unit as described in the Hamilton Official Plan; furthermore, "new neighbourhood" is defined as any neighbourhood presently without substantial development.

3. After the ________ day of __________, 1982, no person shall undertake a development within a new neighbourhood within the City of Hamilton without first filing with the City Clerk, or authorized representative thereof, an Energy Use Assessment.

4. Their Energy Use Assessment with plans, specifications, and calculations forming part thereof shall be in a form prescribed by the Commissioner of Planning for the Corporation of the City of Hamilton.

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*Adopted from City of Ottawa By-law 162-81

EVALUATION

I) This proposed by-law establishes a measuring tool which is available for public scrutiny. Consumers may now inspect the projected energy efficiency of a building and consider this information when making their purchase/rent decision. Assuming that all other purchase/rent considerations are equal, a prospective consumer will select the building that will lower his energy related costs. Hence, this by-law will encourage the builder/developer to incorporate principles of energy efficiency.

II) The by-law does not provide the authority to approve or reject development proposals on the basis of their energy requirements. Furthermore, the by-law does not require that energy efficient principles be incorporated in the proposal. The by-law does require the builder/developer to complete an Energy Use Assessment in order to receive development approval. This will induce a greater awareness and appreciation for the energy requirements development proposals.

III) This is not a radical approach, but a modification of existing practice. Numerous municipalities presently reject development proposals on the basis of their water use, pollution, compatibility, etc. The City of Ottawa has adopted a similar by-law, and very stringent energy impact assessments are common in the United States.

IV) This by-law provides for the collection of energy data necessary for comparison purposes and the development of a comprehensive energy monitoring program. With this strategy, a proposed project's energy use can be compared with the energy use of alternatives such as selection of another site, utilizing passive solar heat gain, altering the street pattern, or increasing insulation levels. A comparison of the alternatives highlights the relative energy efficiency or penalties of a project.

V) The assessment of all development may not be required or justified, as the potential energy savings on all projects would not be significant enough to warrant the assessment. The City of Ottawa limits assessment to all commercial and industrial development as well as residential development exceeding 25 units.

VI) Given the present and near term maturation of energy planning, there is little doubt that voluntary measures backed by clear, straightforward advice will be more effective than a host of new regulations. The review of energy conservation concepts from other municipalities revealed an increased emphasis being placed on market pressure mechanisms to influence energy consumption. The Energy Use Assessment is such a mechanism.

IMPLICATIONS

I) As described, the Energy Use Assessment concept is an essential strategy through which builders become initially concerned with energy efficiency and opt for the PATH approach.

II) An assumption of this strategy is that consumer market pressure, together with the attractiveness of the incentives offered in PATH I or PATH II, will promote energy efficient development without further regulation.

III) Both the Federal and Provincial Governments, in association with builders and developers, are establishing performance standards for the energy efficiency of new residential development. Eventually, these performance standards will be adopted by municipalities throughout Ontario as a required part of the development approval process. The proposed Energy Use Assessment By-law not only determines a building's energy efficiency, but its conditioning effect will ease acceptance of, and conformance to, future energy standards.

IV) During the initial familiarization period, the By-law may slightly increase the cost and time attributed to proposal preparation and approval. However, energy use assessments will soon be normalized as a standard cost associated with the development process, and the effect of increased time and cost will be minimized by the use of existing computer programmes for design and enforcement.

DISCUSSION

PATH I is a prescriptive approach, and PATH II is a performance approach to implementation. PATH I specifies design criteria for new development and PATH II specifies performance standards for energy efficiency. These two distinct approaches establish guidelines that may be used where a developer wishes structures that are more energy efficient. As an encouragement to developers, council may offer incentives depending on the degree of development conformity to the guidelines. The incorporated guidelines could be formalized in development agreements with the municipality.

Why two approaches? The City's present preoccupation with prescriptive planning requires a delivery mechanism to achieve results now while Federal and Provincial authorities establish performance standards. These performance standards, now in their infancy, take the form of energy budgets that are increasingly becoming stringent constraints in the design of public and private development. Initially non-compulsory, energy efficient performance standards could be adopted by municipalities as an alternative to prescriptive criteria. PATH II provides Hamilton with a ready mechanism for adoption and implementation of energy efficient performance standards.

What is PATH I? Essentially, PATH I is this report; the principles and policies detailed earlier together with the control strategies discussed in PART FIVE all attempt to achieve energy conservation given present and near future conditions in Hamilton. These principles, policies, and strategies have been condensed into a "guideline package" for developers and municipal administrators entitled: Energy Efficient Design Criteria Checklist (Appendix "D").

Characteristically, as we shift towards a more conservative era, government involvement or control receives renewed condemnation. An increase in government regulation at any level would not be politically sound nor required, for energy efficient development is dependent on market demand, not government regulation. Hence, new powers granted to municipalities to require energy efficiency in development are not waiting in the wings. Existing municipal powers must be used to reap the benefits of energy efficient land use planning until performance standards are sufficiently developed and demanded by the market.

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Note, the Province appears to be turning a blind eye to municipalities that surpass their legal jurisdiction and require energy efficiency as a pre-requisite to approval. If sensible, such efforts may be inwardly applauded, but if contested the Province will not aid the municipality. Caution: the relative immaturity of energy planning is a warning of the potentially disasterous consequences for the discipline and the municipality that attempt this course of action with poorly developed strategies.

Why is Hamilton developing the PATH II approach? Prescriptive planning practices are a reflection of prevailing societal conditions. As a result, planning often fails to adequately regulate trends in urban development. In response to the changing determinants of urban growth and the inherent rigidity of zoning, the advantages of performance standards were formed into PATH II.

The adoption of performance standards (PATH II) to enforce energy efficiency in neighbourhood development has numerous advantages. For example, PATH II is capable of regulating building design, land use, solar access, and landscaping. The permissiveness of PATH II is derived from the fact that any energy saving scheme(s) can be employed providing the end result complies with the outlined performance target or standard.

Energy policies and design considerations often do not lend themselves to conventional municipal powers based on prescription, for the major reason that not all solutions are necessarily applicable in all situations. It should be emphasized that energy planning requires a tailored response for each development. Furthermore, mandatory conformance, in the absence of verifiable standards, merely increases the inefficiency of bureaucracy. It is not the intent of this study to establish irreplaceable design criteria to enforce energy efficiency. Rather, it is an aim of this study not to unduly increase the regulation of the development process. Hence, a long-range objective of this strategy is to minimize PATH I and maximize PATH II.

Developers generally work on a speculative/competitive basis and there is often a desire to build to basic standards at lowest initial cost. During the initial stages of the learning and adoption curves characteristic of innovation, the development industry will opt for that legislation which offers results while requiring the least effort and cost. At first review, this will appear to be PATH I, and indeed this is the approach most similar to existing development controls. Yet, the performance standard approach of PATH II is most suited for computer design by the developer and computer enforcement by the municipality. The overwhelming time and cost savings offered by computers (computer assisted design: CAD) will favour the PATH II approach in the future.

Why will the Province opt for performance standards for energy efficiency? This question can best be answered by the existence of the Ontario Building Code. The Building Code is the key provincial regulation influencing construction standards throughout the province. A review of the Building Code indicates that this regulation could be considered a comprehensive performance standard approach for development. Presently, all structures in the province are subjected to specific provisions and regulations of the Ontario Bulding Code which have been formulated in accordance with various types of structures. This legislation minimizes the risk of injury and property damage from structural failure, fire and health hazards. This not only establishes the use of performance standards by the Province, but it is conceivable that energy efficiency could be readily incorporated into the Building Code.

In order to incorporate energy concerns as a performance criteria, it is imperative to establish energy budgets or energy efficient performance standards. These performance standards would vary in accordance with the differing types of land use or planning areas. Performance standards ensure minimum variance between similar development in a similar location. Not unlike the Building Code, uniform and consistent application is required. Performance standards allow the Province and development industry to prevent the formulation of municipal energy codes that vary between non-existent and vice-restrictive. The technical explicitness of performance standards also eliminates the majority of arbitrary development decisions made by authorities.

How far off is PATH II realization? The Federal and Provincial governments, together with the development industry are currently developing appropriate standards of energy efficiency for various structural forms. Once established, these standards will take the form of non-compulsory guidelines for development. In time they will likely be legislated and delegated to municipalities in the form of an extension to the Building Code.

The above time factor is a product of the conditioning effect discussed throughout this report. The maturation of energy efficient development is also a major constraint of policy-makers at the provincial level. Their program goals are to develop technological experience and credibility on which to base policy and legislation; and develop favourable public attitude facilitating market acceptance of such technology and legislation. The delivery date for these standards can be hastened by a combination of increases in energy costs and favourable receptivity (successful brainwashing of outdated ideals) by the players in the development industry.

How does PATH II function? Until such time as energy budgets or energy efficient performance standards become legislation and are delegated to the municipality for enforcement, they should remain non-compulsory. Voluntarily, a developer determines for his/her project a performance standard, expressed in kilowatt hours per square metre per year, that is acceptable to the municipality in order to receive development incentives. The guidelines included in Appendix "D" (Energy Efficient Design Criteria Checklist) may be used to achieve this standard. The establishment of specific energy performance standards accompanied by a series of energy guidelines facilitates a significant degree of flexibility since the energy guidelines are non-compulsory, thereby permitting the incorporation of innovative energy conserving techniques.

In order to illustrate a possible energy performance standard for a City of Hamilton CR zone, it is necessary to adopt existing standards appropriate for the land use and area, or calculate a range of energy consumption statistics of office buildings and apartment structures. The mean energy consumption figure for apartment and office buildings has been established from Ontario Hydro statistics. The energy consumption figure for combined office and apartment structures is 47.51 kilowatt-hours per square foot per year, or 162,151.63 BTU. Acknowledging that such structures range in energy consumption from 11 kilowatt-hours to 89 kilowatt-hours, the establishment of an energy performance standard of 28.51 kilowatt-hours (40 per cent below the highest consumption level) is not an unrealistic target for incentive granting, given existing technology. This performance standard would be applicable for structures with a maximum of 600,000 square feet. Such energy consumption figures would have to be calculated prior to construction by a certified engineer.

EVALUATION

I) At this time, PATH I and PATH II are not intended as mandatory requirements. Both PATHS establish an easy and flexible framework by which energy efficiency can be promoted, monitored, and rewarded by incentives.

II) Included in PATH I and PATH II is a list of development incentives offered to developers. Assuming a prospective developer is initially attracted to these "magnetic" incentives, and that he/she complies with the Energy Use Assessment, his/her next step is to incorporate energy conserving measures in the design proposal with the aid of the Energy Efficient Design Criteria Checklist (Appendix "D").

III) Depending on the developer's degree of conformity to either PATH I or PATH II, he/she may be granted a corresponding degree of incentives (page 175). Prior to construction, the municipality and the developer must enter into a legal agreement to ensure compliance.

IV) Although the Province controls the Building Code, either PATH I or PATH II allows the municipality to influence Building Code minimums (usually treated as maximums by builders) by providing incentives to developers to incorporate energy efficient principles in their projects.

V) Aside from providing incentives to developers and implementing Official Plan energy policies, the PATH approach provides a basis on which to field test and monitor energy efficient design principles to determine which are most effective for Hamilton.

VI) The majority of developers unfamiliar with energy efficiency will select the prescriptive approach of PATH I out of convention. It is expected that custom builders desiring greater flexibility will choose PATH II. PATH II is necessary in order not to create new barriers to alternative solutions to energy efficiency.

VII) In the past, developers have indicated concern over stringent requirements of prescriptive and performance standards. In particular, stringent criteria will negate the benefits of incentives. Standards are currently being developed by senior levels of government in co-operation with the development industry for adoption by municipalities and builders. An energy efficient subdivision is currently under development in Flamborough Township according to performance standards determined by the Ontario Ministry of Energy, and the Housing and Urban Development Association of Canada (HUDAC).

VIII) Both PATHS permit developers to comply with Council's policies before officially entering the lengthy approval process. The municipality becomes more involved at the initial stages with the design. This early involvement will be reflected by reduced time required for approval.

IMPLICATIONS

I) Both PATHS help ensure that future neighbourhood development does not become an energy burden on the resident, community, or municipality.

II) The PATH approach bypasses the stigma of increased government regulation and is seen as a reward, not a penalty. The PATH approach also lends itself easily to future amendments.

III) The enforcement of the PATH approach will likely require staff training but should not require additional personnel as the approval process remains the same. City planners will determine the degree of conformance and suggest alternative designs to increase energy efficiency during draft approval. Conformance measures are made a condition of development approval and can be verified by City energy auditors or building inspectors.

IV) The degree of liability normally imposed on the municipality to ensure that the conditions of development agreements are in fact implemented may be broadened to include energy conservation matters.

V) The PATH approach is designed around public education and developer adoption through voluntary measures backed by incentives. Mandatory requirements at this time offer questionable results and would be resisted by the development industry. Most of PATH I and PATH II criteria may be enforced by appropriate legislation. However, the imposition of requirements beyond the stated jurisdiction of the legislation may result in legal action.

VI) Although the two PATHS are not mutually exclusive (indeed, combination may produce desirable results), the City may desire a limited degree of mixture between PATH I and PATH II until both developer and the City become familiar with implementation and implications.

DISCUSSION

The City regulates the planning and development of land and land uses but actual development occurs through the initiatives of the development industry in response to its market. In view of Ontario's present and foreseeable economic environment, and particularly Hamilton's level of development, energy policies must preserve existing amenities and increase Hamilton's desirability as a place to live and do business. Clearly, it is more appropriate to discriminate against energy inefficiency by providing incentives to energy efficient development rather than designating or requiring energy efficiency through increased regulation. Such a strategy supports development industry energy initiatives without regulation or undue hardship.

Development incentives are commonly wielded by Ontario municipalities to provide for such amenities as open space, landscaping, community centres, etc. Similarly, incentives can be offered to developers to actively encourage energy efficiency in their projects.

During development of the PATH strategy, consideration was given to its orientation. Should it be oriented to directly relate the projected energy consumption of a development, or measure its relative energy efficiency? At what degree of conformance does the developer receive incentives: simple regard for energy conservation, conformance to a predetermined percentage, or total complicity?

The study team favoured the orientation that from inception to implementation would be simple and useable, uniform and consistent, provide action and results, and be suitable for computer application. It should be recognized that the level of experience with energy efficient neighbourhood planning is terribly scant in comparison to other planning considerations. With great deliberation we selected the latter orientation which measures a development's relative energy efficiency, and opted for an open ended system which allows experience and professional judgement to decide conformance at the time of application.

Justification for the open ended system: rating or conformance requirements without expensive monitoring would be unreliable, complex, and inconsistent; requirements at this time would meet stiff resistance, lower the appeal of incentives, require yet another approval stage; as the Province is currently developing standards for building energy efficiency to be adopted by the municipality, duplication of effort is undesirable.

The Province is currently experimenting with performance standards for energy efficiency through a number of research and demonstration projects. For example, the energy Efficient Ryerson School Site Project has a design maximum energy budget of 50 kilowatt-hours per square metre per year. These standards could easily be adopted by PATH II and, if need be, modified to reflect technological or cultural advancements.

A checklist combining the elements of this report's earlier sections on principles, policies, and control strategies has been developed for PATH I, and may also be used as a guideline for PATH II (Energy Efficient Design Criteria Checklist, Appendix "D"). A prerequisite for incentive consideration would be submission of the checklist along with the development proposal. The municipality may then ascertain which designs have regard for energy efficiency, their relative degree of conformance, and suggest design improvements.

The appeal of this strategy is that a developer's voluntary efforts are rewarded by incentives to achieve sub-optimal energy savings that condition those involved for Provincial standards at a later date. Potential incentives include any one or a mixture of:

- density bonuses;
- priority processing of proposals;
- reduced development imposts;
- reduced development standards;
- facilitating or incentive zoning;
- low interest loans to developers for the purpose of incorporating energy efficient features;
- municipal recognition program which identifies well planned development/ redevelopment that is energy efficient.

With the exception of the last incentive, which is discussed next, these are not unfamiliar to municipalities and they can be very effective when utilized for purposes of energy efficient land use planning.

Municipal Labelling

The municipality can promote energy conservation through a promotional program of recognition or labelling energy efficient development. Once a development has been determined to be energy saving, the municipality may provide a degree of notification recognizing the development's conservation efforts. The recognition is offered as an incentive to developers who wish to benefit from the potential of such a marketing aid.

Naturally, the determinant is the development's degree of conformance to the energy efficient guidelines contained in the PATH approach. PATH I and PATH II are tailored for Hamilton to be sufficiently sensitive to reflect a wide range of conservation measures. The PATH approach was purposely designed to accommodate provincial labelling standards at a future date.

The major objectives of a labelling program are:

- to encourage developers and builders to construct energy efficient homes by providing an award system which acknowledges the energy efficient features of the house;

- to enable consumers to make more informed purchasing decisions by providing them with a means of identifying energy efficient homes and their features;

- to increase consumer demand for energy efficient homes by highlighting the benefits of such development;

- to verify and monitor the energy conserving features and ensure that they have been provided and perform as expected;

- to condition consumers and the development industry for the more stringent energy standards currently being established by both the Provincial and Federal governments.

It should be emphasized that the increased value of an energy efficient home will not be reflected in the marketplace until consumers are willing to pay for energy efficiency. Consumer acceptance of a municipal labelling program would encourage the development industry to give greater consideration to energy efficiency.

The labelling concept is similar to the E.P.A. rating of automobiles, in that municipal recognition or labelling would not constitute an express or implied warranty of a home's energy efficiency. In fact, the E.P.A. rating disclaims the accuracy of its own figures but receives widespread use and credibility. Rather, municipal labelling would be used for comparison purposes only; relieving the municipality of any liability burden.

Essentially, the recognition program would consist of a uniform label or plaque similar to Figure ...., which may be included in the developer's marketing strategy. For example, a newspaper advertisement describing a particular development, if granted, may also include a label indicating that the municipality approves this development as energy efficient.

The amount of energy required to heat a house depends on: the heat loss characteristics of the structure; the local climate; fuel utilization efficiency; and the amount of internal heat gain. Ideally, an optimum labelling program would incorporate these factors as completely as possible. However, the municipality possesses neither the resources nor jurisdiction to establish such data for labelling. Note: it is the role of the Province to set required standards for energy conservation in housing.

Several organizations are currently developing programs for the evolution of buildings to determine their relative energy efficiencies (e.g. National Research Council of Canada, Canadian Standards Association, Housing and Urban Development Association of Canada, Ministry of Energy, etc.).

The National Research Council has developed a program which, together with design competitions and energy budgets for builders, creates a basis for building energy performance standards that will undoubtedly be required in the future. During the interim period the above strategy, toghether with the PATH approach, will achieve sub-optimal results.

Part Six

Appendices

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Appendix A

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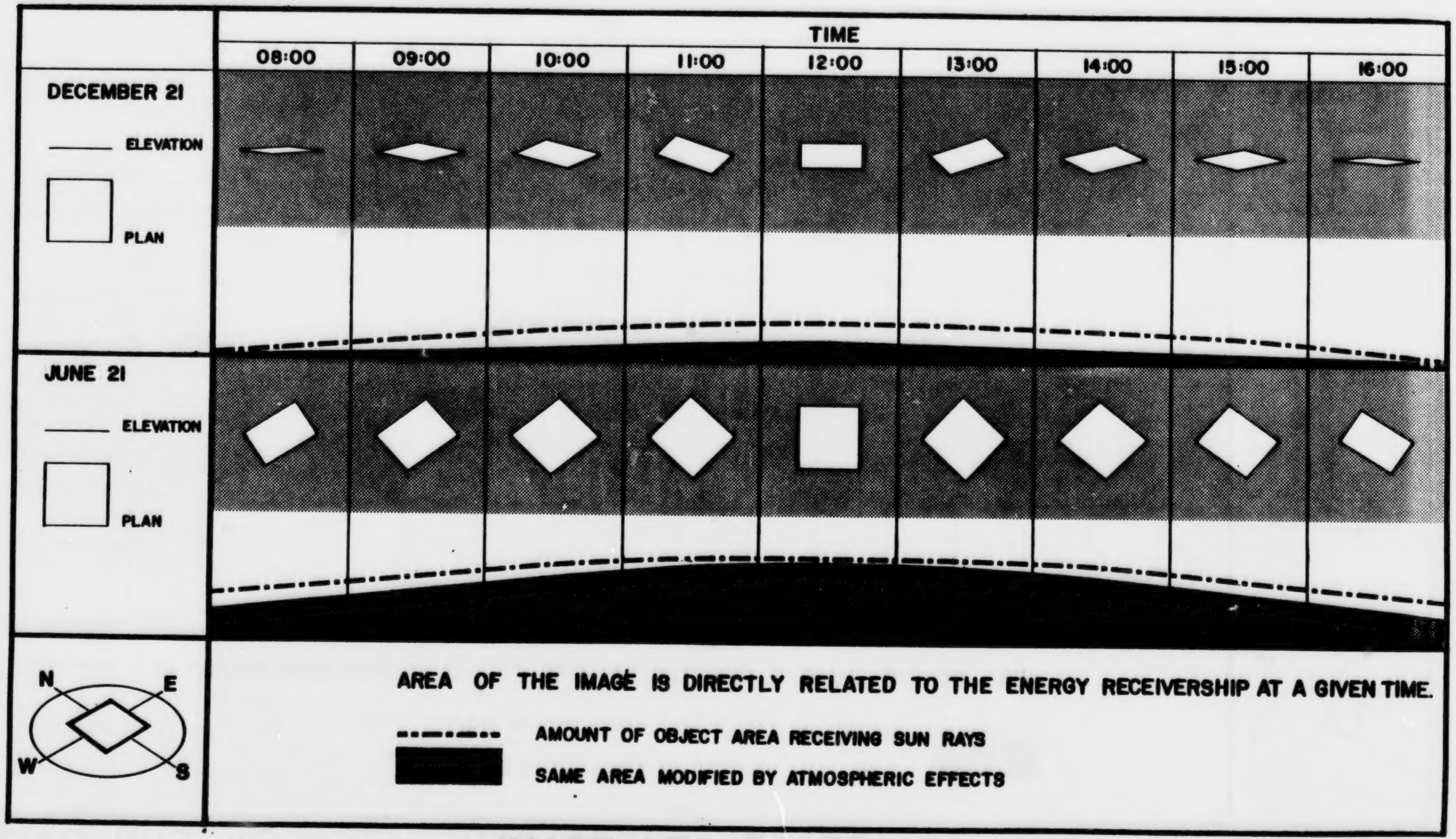
Image of Object Generated by Sun Rays

Appendix B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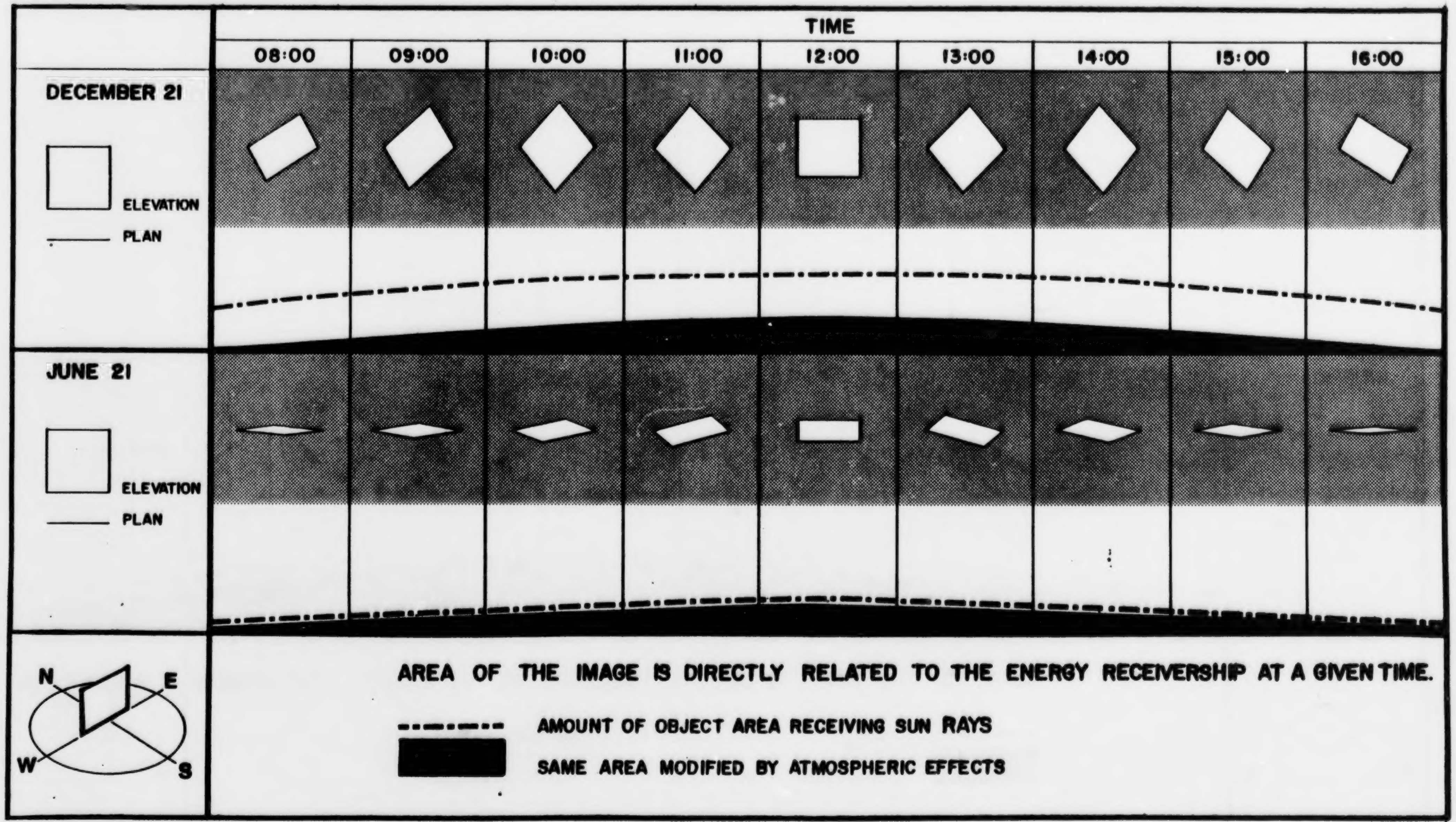
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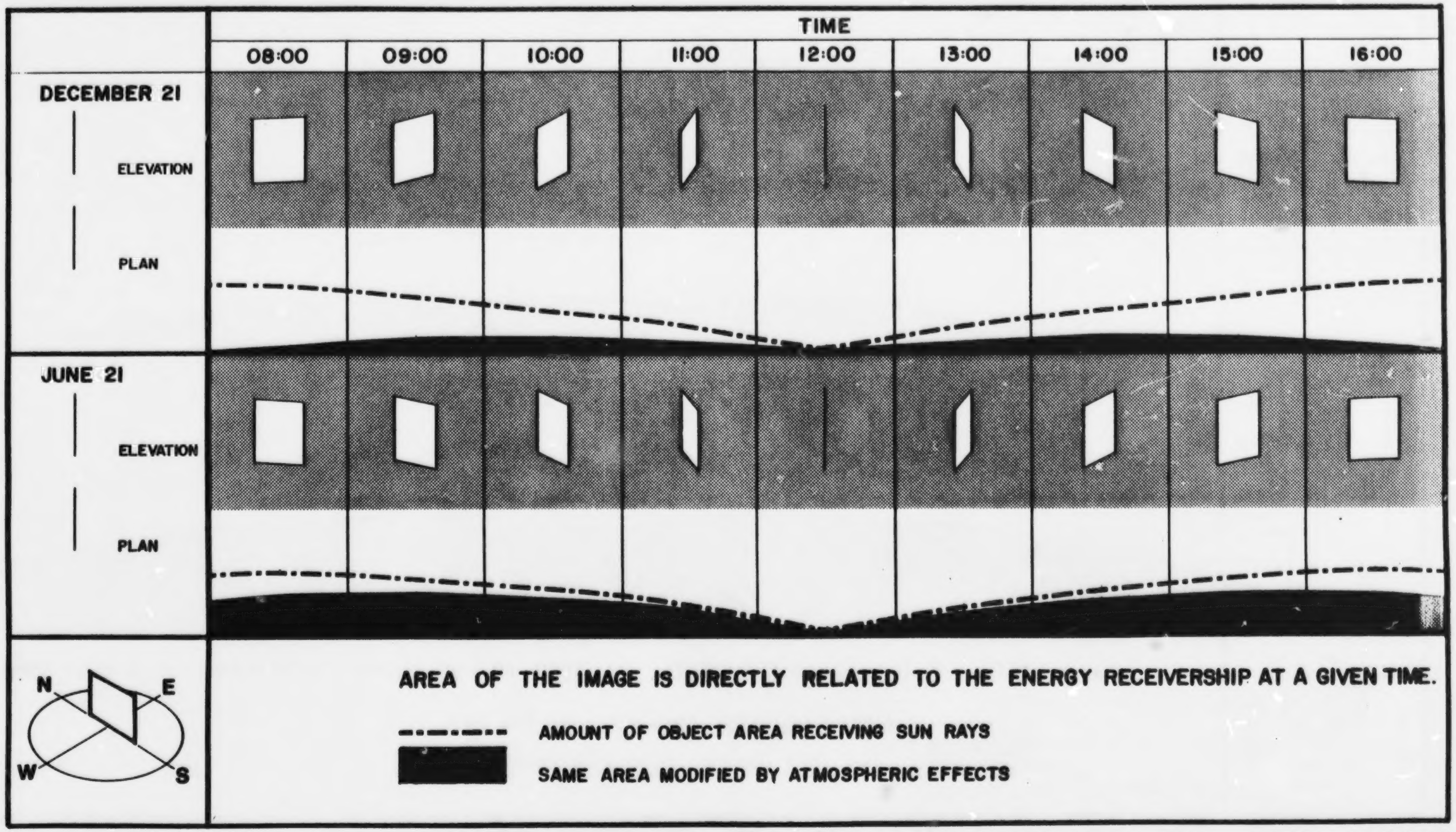
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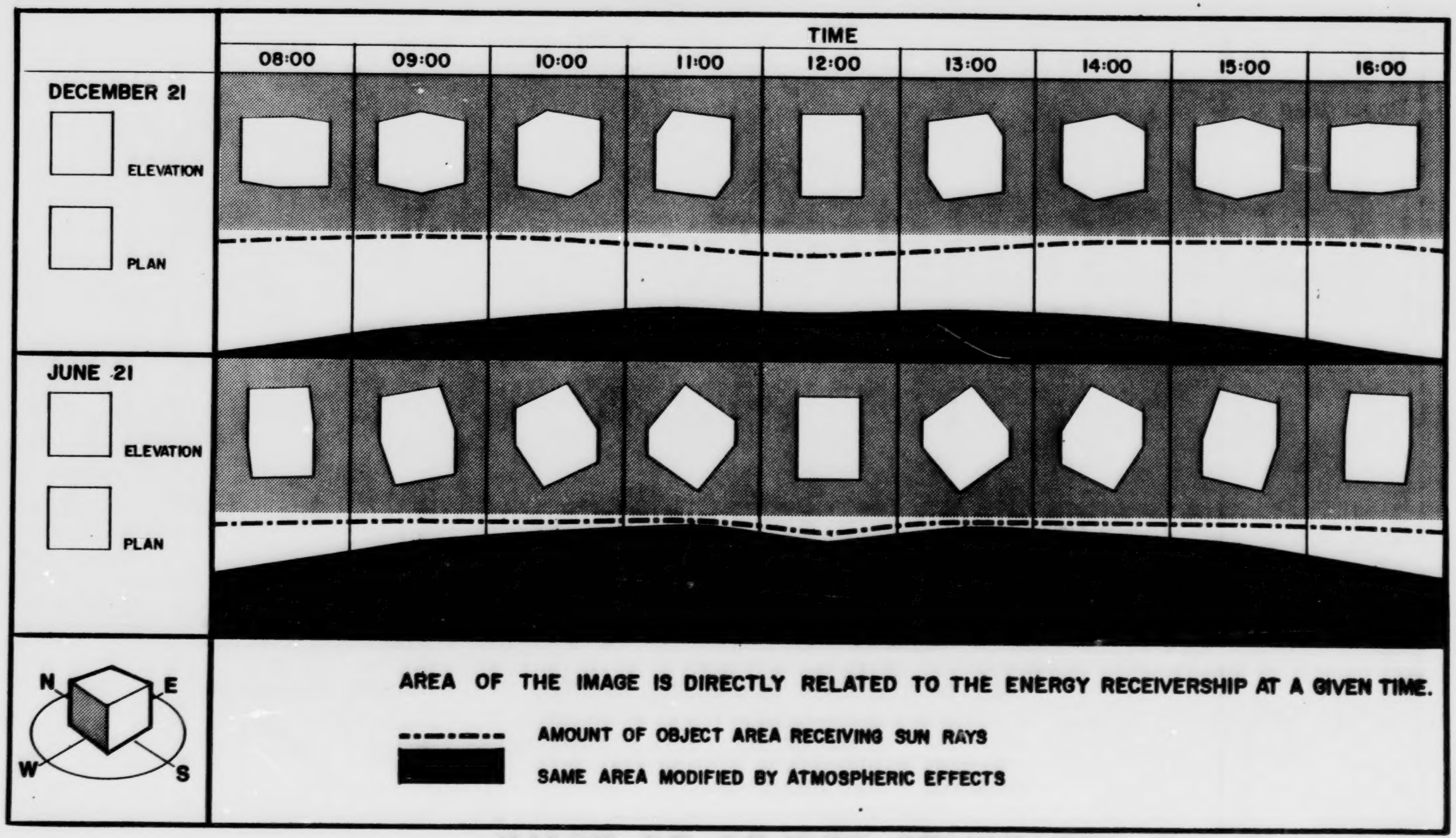
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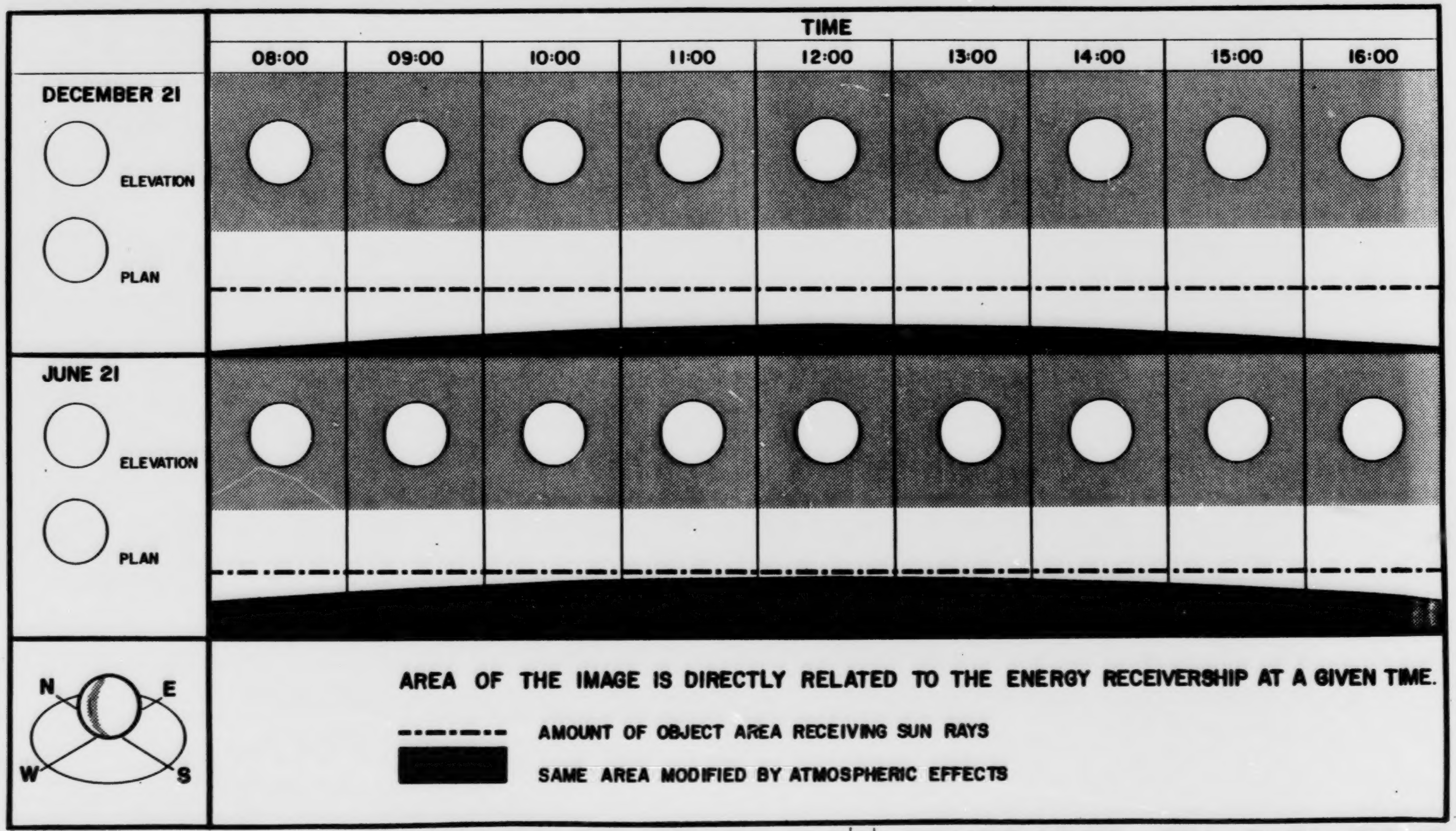
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Inventory of Neighbourhood Development Concepts to Increase Energy Efficiency

Appendix C

ALBUQUERQUE, NEW MEXICO

Description

(1977) City amended height regulations for medium and high density residental and certain non-residential zoning districts. The height restriction is defined by three dimensional building envelopes within which buildings must be contained.

Evaluation

-Existing height regulations were simply adjusted downwards, using 45 and 60 degree angles because they are common, provide a degree of solar access protection without severely restricting building height, and can be reviewed with standard drafting triangles.

-This strategy is more appropriate for "infilling" where tall buildings may be designed and located in a manner which also guarantees solar access to surrounding structures.

Implications

-The majority of new neighbourhood development in Hamilton will continue to be medium to low rise at relatively low densities; this form of development together with existing development standards and zoning, in most cases, ensures appropriate solar access without amending height restrictions.

-The City of Hamilton already possesses a superior planning tool for assuring solar access in new neighbourhoods through Solar Envelopes which is described in the report, Planning for Low Density - A Solar Approach.

-This strategy is inappropriate for this study, but will be retained and reconsidered when the City turns its attention to the energy efficiency of existing land uses.

BOULDER, COLORADO

Description	Evaluation	Implications
(1977) Boulder has a growth management system that limits the number of development permits issued each year. If more permits than the number allocated are sought by developers, then they must compete for them based on a point system. Bonus points are awarded to developers for projects containing energy efficient land use planning features.	-Once the allocated number has been reached, in order to receive development approval, developers obtain bonus points by including energy conservation features. -The design features most commonly incorporated include: extra insulation, water conservation devices, heat pumps, passive solar orientation, and the strategic placement of shade trees and windbreaks. -The site features most commonly incorporated include: close proximity to existing neighbourhood park, public transit, library, day use, shopping, recreational centre, schools.	-Aside from the howl of development industry protest such an allocation system would receive, it is legally inappropriate for Hamilton and there is not a sufficient number of development proposals in Hamilton to justify establishing such an award system. -This merit approach is similar to controls often covertly placed on development; what distinguishes the Boulder approach is the explicit nature of the evaluation criteria and the use of a competitive, rather than regulatory, mechanism. -In addition, Boulder exercises development control through growth management (i.e. performance standards) which, in itself, is more flexible and inviting to energy efficient land use planning. -A more appropriate strategy for Hamilton would be the adoption of the "Energy Efficient Design Criteria" (Path I) and "Energy Efficient Performance Standard" (Path II); which together with developer incentives awarded for a high degree of compliance, would offer similar results suited for the Hamilton context (PART FIVE).

BEDFORD, NOVA SCOTIA

Description	Evaluation	Implications
(1974) Municipality designs a 38 hectare (94 acre) subdivision through such energy conserving techniques as: i) Cluster development ii) Natural drainage iii) Narrow roads iv) Optimum orientation v) Building design	i) Cluster housing reduces lot size but increases open space and facilitates commpact development form. It also reduces servicing and infrastructure costs. ii) The design recognized that storm sewers, basement perimeter drains, catch basins, street curbing, and overland ditch networks were unnecessary cost and energy expenditures. As an alternative, drainage swales were incorporated into the roadway design and drains discharged directly into natural water storage areas. iii) Pavement widths were reduced from 10 m (32 ft.) to 6 m (20 ft.). Natural drainage made the former allowance for storm sewers and gutters unnecessary. iv) Dwellings were oriented to maximize passive solar gain, allocate open space on the south side, reflect sunlight into common areas, and deflect the wind from living areas. v) Energy efficient building design includes: triple glazing on all north and west exposures, insulating shutters, R-20 insulation in walls and R-30 in ceilings.	Prices for homes in this subdivision are expected to be $10,000 below the average for conventionally built housing in the immediate area. Cluster housing is an excellent strategy for energy efficiency; unfortunately, it has yet to win consumer preference. As discussed throughout pages 142 to 145, reduced development standards offer huge energy savings.

BRAMPTON, ONTARIO

Description	Evaluation	Implications
(1979) The City developed an energy conservation criteria which is applied to future development; the City has prepared a comprehensive energy policy statement for incorporation in the Official Plan; and the City has passed a by-law enforcing building solar orientation and the protection of solar access in specific developments.	-The strategy of establishing an energy conservation criteria is sound, for it allows the municipality to actively promote energy efficient design as well as judge the energy efficiency of development proposals. -The energy conservation criteria is supported by Official Plan policies but in fact is only legally binding if imposed as conditions of approval. In other instances, the criteria and policies are used as statements of intent for use in development negotiations. -The solar by-law surpasses the legal authority of a municipality and, if contested by developers in court, would likely fail. Success is guaranteed by developer consent. -Compliance to Council's criteria and by-law, in one instance, resulted in the economic loss of one lot with an 80 per cent degree of conformity.	-The development of the Path I strategy for Hamilton is a more detailed and specific planning tool, but is not dissimilar in approach to Brampton's energy conservation criteria. The addition of Path II steps beyond the pioneering prescriptive approach and denotes greater accuracy and maturity in energy efficient land use planning (page 168). -Hamilton should re-evaluate its energy goals and objectives in light of this study to develop more appopriate energy policies. For coherence, clarity, emphasis, and enforcement, these redesigned policies should be placed in context with the provisions they influence. Only the more general "motherhood statements" should be placed in a separate "Energy Section". -With full respect for the fact that Brampton's solar by-law was a pioneering effort in Canada, the strategy already developed by the City of Hamilton and described in this report and Planning for Low Density - A Solar Approach is more effective, similar to existing development controls, and within the legal authority granted municipalities.

CAMBRIDGE, ONTARIO

Description

(1981) The Regional Municipality of Waterloo, of which the City of Cambridge is a part, possesses the authority to approve and extend draft plan of subdivision. Cambridge recommends and has no objection to the extension of draft approval of plan of subdivision provided the following conditions of draft plan approval are amended to include:

1. Minimum insulation in every dwelling unit to the value of R 28 in roofs and R 20 in exterior walls.
2. Minimum roof overhang of 0.6 metres over any exterior wall containing windows with a southerly or westerly exposure.
3. All windows in exterior walls at least double glazed.
4. Sufficient window area in the southerly and westerly exterior walls of a dwelling to take advantage of passive solar heat.
5. Natural gas installed in all areas where natural gas is available.

Evaluation

1. The Ontario Building Code now requires R 28 for gable roofs, R 20 for flat roofs, and R 12 in exterior walls. Any condition exceeding these requirements could be successfully challenged by the developer. If levels of insulation are included in a subdivision agreement, the municipality is liable for ensuring that the levels stated are installed.
2. The optimum size of a roof overhang is dependent upon window height and orientation, and would vary significantly from a prescriptive standard of .6 metres. A .6 metre roof overhang on a two storey building would be of no value to windows on the bottom floor.
3. The Building Code presently requires windows to be double glazed or fitted with storm windows.
4. The Building Code requires that window area for habitable rooms be a minimum of 10% of the floor area. Cambridge's condition requires a value in order to be of any use, and this would again be in contravention of the Building Code.
5. Natural gas is presently installed in areas where it is available because of senior government policies and relative economic advantages.

Implications

It is recognized that this strategy is a pioneering attempt and should be applauded for its forceful efforts.

The Ontario Building Code is presently under review with the amended version supposedly incorporating a greater awareness of energy efficiency.

This strategy is either legally unacceptable or inappropriate for Hamilton; the design conditions suggested by Cambridge are provided for in PATH I or PATH II.

As in the draft plan approval stage as well as the extension of draft plan approval, Hamilton should use the strategies developed in PATH I or PATH II to encourage and/or require energy efficient development. There are 17 development approvals lapsing in Hamilton during 1982.

CLINTON COUNTY, MICHIGAN

Description	Evaluation	Implications
(1979) The County developed detailed energy policies for inclusion in the Official Plan. In order to implement these policies specific changes to the zoning by-law were necessary:		
1) A reduction in the minimum floor area for single storey houses.	1) The smaller size would contribute to slightly lower construction costs, significantly reduced heating and cooling requirements, and facilitate increased densities.	1) Reduced minimum floor areas is a reasonable strategy to promote energy efficiency as well as the development of neighbourhoods with homes built for those persons at the beginning or latter stages of the housing cycle.
2) Wind energy convertor towers and windmills are a permissable land use in low density residential areas.	2) In many areas wind energy offers greater potential than solar energy. Not unlike underground homes, the potential for wind energy use in neighbourhoods is so far beyond our cultural and psychological values that it is rarely imagined, much less addressed.	2) Wind energy is a viable alternative to conventional energy in certain situations. Recognition of this increases the effectiveness of a municipality's energy policies. Hamilton should remove undue barriers against the use of wind energy convertor towers (windmills) in low density development, thereby enabling, rather than promoting, their use at this time.
3) Inclusion of a solar variance for solar energy systems added to existing buildings.	3) The solar variance approach to removing barriers against solar energy utilization could be expected to reduce the number of zoning changes, but variances would have to be processed on a case-by-case basis.	3) This strategy is more suited to retrofit measures and is inappropriate for new neighbourhood development in Hamilton. It assumes that variances will be required to correct faulty design in order to effectively utilize solar energy systems. Our strategies ensure from the beginning that development design will facilitate the use of solar energy.

COLORADO SPRINGS, COLORADO

Description

Council adopted a zoning provision which permits the use of solar energy systems in all areas of the City by exemption from accessory structure and lot coverage restrictions.

Evaluation

-This provision attempts to reduce several barriers against the use of solar energy systems, which on a per capita basis are in greater use in the United States than Canada. This provision also reflects a greater promotion of active solar energy systems, which, at this time, is inappropriate for Hamilton.

-The City possesses neither a complimentary by-law assuring southern orientation nor solar access. Solar energy systems are still subject to height and setback limitations. The issue of whether to allow solar energy systems as a permitted use is particularly sensitive in heritage districts, where regulations may require that the exterior of buildings conform to special design guidelines.

Implications

-Height, yard projections, accessory structures, lot coverage, overhangs, setback limitations, and other restrictions often contained in zoning by-laws may prevent or discourage the use of passive and, at a later date, active solar energy systems.

-A more appropriate strategy for new neighbourhood development: Council may, at its discretion, permit the use of alternative energy systems, including their related components, for space and water heating or cooling, and electrical energy generation. Solar access and orientation are assured by the PATH approach and Solar Envelopes.

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS						
		1	2	3	4		
Legality	Illegal					●	Legal
Sophistication	Complex			●			Simple
Degree of Innovation	Innovative			●			Traditional
Cost/Benefit Analysis	Inferior		●				Superior
Experience Results	Negative		●				Positive
Environmental Constraints	Dissimilar		●				Similar

SIFT II

OPTION:

Alburquerque

SIFT I RANK: 17

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION						
	MODIFICATION		●				●
	NEW CONTROLS						

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS						
		1	2	3	4	5	
Legality	Illegal	●					Legal
Sophistication	Complex				●		Simple
Degree of Innovation	Innovative		●				Traditional
Cost/Benefit Analysis	Inferior					●	Superior
Experience, Results	Negative					●	Positive
Environmental Constraints	Dissimilar	●					Similar

SIFT II

OPTION:

Boulder

SIFT I RANK: 18

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION						
	MODIFICATION						
	NEW CONTROLS	●	●	●	●	●	●

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS						
		1	2	3	4*	5	
Legality	Illegal				●		Legal
Sophistication	Complex				●		Simple
Degree of Innovation	Innovative				●		Traditional
Cost/Benefit Analysis	Inferior				●		Superior
Experience/ Results	Negative				●		Positive
Environmental Constraints	Dissimilar				●		Similar

SIFT II

OPTION:

Bedford

SIFT I RANK: 24

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION						●
	MODIFICATION		●				●
	NEW CONTROLS						

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS						
		1	2	3	4	5	
Legality	Illegal		●				Legal
Sophistication	Complex			●			Simple
Degree of Innovation	Innovative			●			Traditional
Cost/Benefit Analysis	Inferior				●		Superior
Experience/ Results	Negative				●		Positive
Environmental Constraints	Dissimilar					●	Similar

SIFT II

OPTION:

Brampton

SIFT I RANK: 21

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION						
	MODIFICATION	●		●			
	NEW CONTROLS		●				

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS						
		1	2	3	4	5	
Legality	Illegal		●				Legal
Sophistication	Complex			●			Simple
Degree of Innovation	Innovative				●		Traditional
Cost/Benefit Analysis	Inferior				●		Superior
Experience, Results	Negative				●		Positive
Environmental Constraints	Dissimilar					●	Similar

SIFT II

OPTION:

Cambridge

SIFT I RANK: 22

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION						
	MODIFICATION		●				●
	NEW CONTROLS		●				●

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS						
		1	2	3	4	5	
Legality	Illegal				●		Legal
Sophistication	Complex				●		Simple
Degree of Innovation	Innovative			●			Traditional
Cost/Benefit Analysis	Inferior		●				Superior
Experience/ Results	Negative			●			Positive
Environmental Constraints	Dissimilar				●		Similar

SIFT II

OPTION:

Clinton

SIFT I RANK: 22

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION			●			
	MODIFICATION						●
	NEW CONTROLS						

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS						
		1	2	3	4	5	
Legality	Illegal				●		Legal
Sophistication	Complex			●			Simple
Degree of Innovation	Innovative			●			Traditional
Cost/Benefit Analysis	Inferior		●				Superior
Experience/ Results	Negative		●				Positive
Environmental Constraints	Dissimilar		●				Similar

SIFT II

OPTION:

Colorado

SIFT I RANK: 16

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION						●
	MODIFICATION						
	NEW CONTROLS						

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS						
		1	2	3	4	5	
Legality	Illegal					●	Legal
Sophistication	Complex			●			Simple
Degree of Innovation	Innovative				●		Traditional
Cost/Benefit Analysis	Inferior			●			Superior
Experience/ Results	Negative				●		Positive
Environmental Constraints	Dissimilar	●					Similar

SIFT II

OPTION:

Dade County

SIFT I RANK: 20

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION						
	MODIFICATION	●	●	●	●	●	●
	NEW CONTROLS						

DADE COUNTY, FLORIDA

Description	Evaluation	Implications
(1975) Site plan review process was amended to promote energy efficent design of new development. A list of energy-efficient review criteria was established and planners negotiate their implementation with developers.	-Developers are not legally required to comply with the energy efficient design criteria, rather, they are items for negotiation. -The criteria are applied informally and only marginally add to the existing administrative and approval process. -Compliance has not been a problem, especially for such measures as landscaping of common areas/paved areas and providing shading devices. -The main difficulty has been site inspection and enforcement of the imposed conditions. -Negotiation for implementation may involve hard bargaining which may be fruitless unless the developer is cooperative.	-Dade County's adoption of design criteria to promote energy efficient development is a passive approach which relies on municipal encouragement and initiative to negotiate and obtain developer cooperation. The concept is quite good, but the strategy lacks the detail, incentives, and enforcement necessary for optimum success. The implementation of such a concept will likely require staff training and possibly additional or redistributed personnel. -The strategies developed for Hamilton, PATH I and PATH II, are more specific in approach and contain measures with greater sophistication to promote energy efficient land use planning.

DAVIS, CALIFORNIA

Description	Evaluation	Implications
(1973) The City reduced its pavement width standard for local and minor arterial roads to 7 metres in order to reduce embodied energy needs.	-This is a very good strategy, for the embodied energy costs of excessively wide streets are high. Reduced development standards are promoted by the Federal and Provincial governments, as well as HUDAC and UDI, as strategies to increase the energy efficiency of development.	-Such a strategy will likely meet bureaucratic and cultural resistance. -Parking bays would eliminate congestion concerns, and the municipality maintains ownership of the standard right-of-way for access by emergency vehicles and snow clearing. -Reduced pavement widths would ideally be granted as a development incentive for projects which conform to either PATH I or PATH II.

DAVIS, CALIFORNIA

Description	Evaluation	Implications
(1977) City attempts to reduce work related commuting by allowing greater home occupations.	-This ordinance is a performance standard which sets minimum levels of performance for home occupations rather than listing specific types. -The application for home occupations is handled by the planning staff. -This is another example of a concept that enables (rather than regulates) residents to undertake an energy-conserving practice. -Home occupations have the potential to reshape our neighbourhoods while promoting energy efficiency: e.g., reduce the embodied energy of transportation system requirements, reduce transpsort fuel consumption, facilitate mixed land use, and reduce the need for massive work centres built and maintained for 24 hours while utilized for 7.	-The barriers are cultural and institutional. -Hamilton should modify its present home occupation prescriptive standards and adopt a performance approach such as: i) only one non-family person may be hired. ii) products cannot be sold from home. iii) no more than 25% of any one floor of the residence is to be used for the business. -Performance standard approach does not limit the range of possible home occupations but, rather, limits aspects that could cause nuisances.

DAVIS, CALIFORNIA

Description	Evaluation	Implications
(1977) City adopts ordinance which requires increased levels of landscaping for all new commercial developments, as well as multi-family and commercial paired parking lots to reduce space heating and cooling, and provide a more comfortable pedestrian environment.	-Proposed commercial developments must provide a landscaping plan that details vegetation location, species, and shading; proposed landscaping must cover at least 10% of the site. Proposed commercial and multi-family paved parking lots must be 50% shaded by tree canopy within 15 years of the issuing of building permit. -These shading and landscaping measures were adopted for hot summers to reduce the excessive use of air conditioners. The required shading levels for commercial and multi-family paved parking lots to provide a more comfortable pedestrian environment merits consideration but, in view of the fact that Hamilton summers are not terribly hot, the increased development and maintenance costs may outweigh any aesthetic or energy gains. -Such landscaping measures are most applicable to very low density development where there is ample land for them to be employed. In a typical Hamilton neighbourhood development, the placement and form of the buildings themselves dictate the micro-climate. The use of landscaping (aside from the obvious, i.e., ensuring that conifers do not shade south glazing) to modify micro-climate conditions is unproductive at the proposed plan review stage; until experience dictates otherwise, the judicious placement of vegetation to increase energy efficiency can only be made after construction.	-This report recommends that shadow projection plans for all natural and man-made features be required as part of development approval. -Landscaping principles are contained in this report and should be encouraged as part of a total ecological approach to energy efficiency. -Presently, landscaping is often a condition of subdivision, or site plan approval, for aesthetic and buffer reasons. Aside from the obvious "do's and don'ts" regarding vegetation placement, it is recommended that a provision in the Official Plan "have regard for" the energy efficient design of landscaping. This will suffice until the effectiveness of landscaping to reduce energy consumption is further explored.

DAVIS, CALIFORNIA

Description	Evaluation	Implications
(1979) City integrates yard projections to allow the greater use of sun devices to prevent summer over heating and reduce energy used for space cooling. (1977) The City nullified existing covenants and prohibited future regulations banning the use of clotheslines, and also required all multi-family residential developments to provide facilities and space for outdoor clothes drying. (1981) City requires all homes to be retro-fitted to specified energy conservation standards before they can be sold.	-De-regulation or the removing of barriers are relatively non-controversial issues that promote energy efficiency; easily implemented without negative implications, and may be supported without detailed studies and quantitative calculations.	-Promoting the use of clotheslines is a sound concept and the City should ensure that there are no prohibitions against their use at the neighbourhood level. However, actively mandating the use of clotheslines is too paternalistic, and inappropriate for Hamilton's environment. -Requiring that homes conform to energy conservation standards is an excellent, although stringent, strategy. This would also have to be a Provincial responsibility similar to automobile certification. -Architectural design is not within a municipality's jurisdiction.

DAVIS, CALIFORNIA

Description	Evaluation	Implications
(1979) The City deregulated fence set-backs to prevent interference with passive solar heat gain.	-The new provision does not require more administrative time as a standard has simply been changed, not added. -This ordinance does not guarantee that fences will be placed in a way that will permit solar access. Since this amendment is enabling, rather than prescriptive, any energy savings depend on the resident, or developer.	-This strategy applies more to Davis' large estate lots and Spanish style architecture, and is not appropriate for Hamilton's neighbourhood development or overall energy strategy. -Hamilton experience shows that residents opt to locate fences, often illegally, to maximize private spaces. Adoption of the Davis ordinance would affect the value of the lot as well as a resident's preferred fence or hedge placement. Singling out such landscaping features is a retro-fit solution to the protection of solar access. -To ensure the effective use of passive solar heat gain in new neighbourhood development, Hamilton should adopt Solar Envelopes as well as the design guidelines of PATH I and PATH II.

DOUGLAS COUNTY, KANSAS

Description	Evaluation	Implications
(1978) County Council amended its zoning ordinances to permit the development of underground homes as permanent dwellings in all areas.	-Traditional zoning and development regulations do not even consider the potential development of underground homes and often restrict dwellings below grade. -There is a wealth of knowledge and demonstrations expounding the benefits of underground homes, but little has been accumulated in Canada. -The psychological and cultural barriers against such development are presently too strong to encourage neighbourhood construction of this kind. Even Douglas County has yet to receive an application for development consideration or approval.	-Hamilton can begin to reduce similar barriers by permitting the development of underground, extensively bermed, or permanent dwellings below grade, in specific areas of new neighbourhood development through amendments to the Official Plan and Zoning By-law. -Amendments would not encourage, merely enable. Such a low key approach would be compatible with this strategy's low priority for action.

FERMONT, QUEBEC

Description

(1971-77) A new resource community in the Sub-Arctic introduced concepts that resulted in a number of energy efficient features:

-Gross density of 65 persons/hectare (26 persons/acre).

-Created a continuous five and a half storey building about one kilometre long to screen the community from winter winds. Coniferous trees were also retained to shelter structures.

-Climate controlled pedestrian access to community facilities.

-Comprehensive walkway system, and the use of "T" type intersections.

-A variety of housing designed with energy efficient features.

Evaluation

-Compact densities decrease area and capital demands for public services and rights-of-way. This provides additional reductions in funds needed for maintenance, landscaping, policing, etc.

-The mixed use building creates a "wind-shadow" that reduces infiltration and loss of heat. Analyzed wind patterns determined: street design for optimal dissemination of snow; low pitch roofs minimize snow loading; southern exposure helps diminish snow buildup.

-The mixed use building incorporates residential, education, shopping, and recreation facilities. Functions are located according to their lighting and heating requirements, i.e. shopping on the windward side and education on the protected and naturally lit side.

-Compact design encourages pedestrian movement. Sidewalks on the south side of roadways facilitate snow melting and free the north side for storage. "T" type intersections minimize stop signs.

-Building Design includes: electric space heating, passive solar gain, vestibules, and garages that extend beyond the house to minimize driveway length, cost and snow removal.

Implications

-Fermont has 2.3 m per person of public rights-of-way, only a quarter that of a conventional town of similar size. This translates into a savings of $8,000,000 (1976 dollars) in capital costs. The adoption of compact urban form and increased densities can offer similar savings in Hamilton.

-Via model simulation, the wind sheltering of buildings by other buildings is an excellent design strategy as long as shadow patterns are considered.

-Fermont's windscreen building/mixed land use concept may be directly incorporated for use in Hamilton's neighbourhood planning of multi-purpose community centres.

-Snow storage and drifting are not as major a design consideration in Hamilton. "T" type intersections, because of their perpendicular angles, preclude winding streets and facilitate increased densities with solar access.

-As in Hamilton, the design of dwellings in Fermont responded to demands of residents who preferred to live in detached homes. Hence, the conventional housing form was modified to increase energy efficiency.

KING COUNTY, WASHINGTON

Description	Evaluation	Implications
(1979) County adopts zoning and Official Plan amendments to remove regulatory barriers to encourage increased density development to facilitate energy efficient land use planning.	-Townhouses are now permitted uses in any residential zone. -The approval process for townhouse development has been hastened. -The maximum density for single-family zones was increased.	-In Hamilton, present to near future market conditions will continue to promote single-family detached dwellings and provide little impetus for the development of medium to high density housing; unfortunately, consumer values and energy efficient neighbourhood planning are in conflict, for single-family detached housing is the most energy inefficient form of development. -Not unlike underground housing, the active encouragement of increased densities to facilitate energy efficiency would become a most contentious issue perceived by the general public and development industry as being out of step with reality and vested interests; such an approach would receive little political support. -However, a low-key, sub-optimal approach for Hamilton would be to remove development barriers prohibiting increased densities to enable, not necessarily encourage, such development at a later date when they are once again desired.

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS	1	2	3	4	5	
Legality	Illegal					●	Legal
Sophistication	Complex				●		Simple
Degree of Innovation	Innovative			●			Traditional
Cost/Benefit Analysis	Inferior					●	Superior
Experience/Results	Negative				●		Positive
Environmental Constraints	Dissimilar		●				Similar

SIFT II

OPTION:

Davis

SIFT I RANK: **23**

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION						●
	MODIFICATION					●	
	NEW CONTROLS						

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS	1	2	3	4	5	
Legality	Illegal				●		Legal
Sophistication	Complex				●		Simple
Degree of Innovation	Innovative	●					Traditional
Cost/Benefit Analysis	Inferior			●			Superior
Experience/Results	Negative				●		Positive
Environmental Constraints	Dissimilar		●				Similar

SIFT II

OPTION:

Davis

SIFT I RANK: **18**

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION			●			
	MODIFICATION						
	NEW CONTROLS						

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS	1	2	3	4	5	
Legality	Illegal			●			Legal
Sophistication	Complex			●			Simple
Degree of Innovation	Innovative		●				Traditional
Cost/Benefit Analysis	Inferior		●				Superior
Experience/Results	Negative		●				Positive
Environmental Constraints	Dissimilar		●				Similar

SIFT II

OPTION:

Davis

SIFT I RANK: **14**

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION						
	MODIFICATION						
	NEW CONTROLS						●

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS	1	2	3	4	5	
Legality	Illegal	●					Legal
Sophistication	Complex				●		Simple
Degree of Innovation	Innovative	●					Traditional
Cost/Benefit Analysis	Inferior					●	Superior
Experience/Results	Negative				●		Positive
Environmental Constraints	Dissimilar		●				Similar

SIFT II

OPTION:

Davis

SIFT I RANK: **17**

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION						
	MODIFICATION						
	NEW CONTROLS		●				

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS	1	2	3	4	5	
Legality	Illegal				●		Legal
Sophistication	Complex			●			Simple
Degree of Innovation	Innovative				●		Traditional
Cost/Benefit Analysis	Inferior		●				Superior
Experience/Results	Negative				●		Positive
Environmental Constraints	Dissimilar		●				Similar

SIFT II

OPTION:

Davis

SIFT I RANK: **19**

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION		●				
	MODIFICATION						
	NEW CONTROLS						

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS	1	2	3	4	5	
Legality	Illegal			●			Legal
Sophistication	Complex				●		Simple
Degree of Innovation	Innovative	●					Traditional
Cost/Benefit Analysis	Inferior				●		Superior
Experience/Results	Negative			●			Positive
Environmental Constraints	Dissimilar		●				Similar

SIFT II

OPTION:

Douglas County

SIFT I RANK: **17**

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION						●
	MODIFICATION		●				
	NEW CONTROLS						

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS	1	2	3	4	5	
Legality	Illegal					●	Legal
Sophistication	Complex				●		Simple
Degree of Innovation	Innovative				●		Traditional
Cost/Benefit Analysis	Inferior				●		Superior
Experience/Results	Negative				●		Positive
Environmental Constraints	Dissimilar			●			Similar

SIFT II

OPTION:

Fermont

SIFT I RANK: **24**

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION						
	MODIFICATION	●	●	●	●	●	●
	NEW CONTROLS						

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS	1	2	3	4	5	
Legality	Illegal					●	Legal
Sophistication	Complex				●		Simple
Degree of Innovation	Innovative			●			Traditional
Cost/Benefit Analysis	Inferior			●			Superior
Experience/Results	Negative		●				Positive
Environmental Constraints	Dissimilar			●			Similar

SIFT II

OPTION:

King County

SIFT I RANK: **20**

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION				●		
	MODIFICATION				●		
	NEW CONTROLS						

MONTGOMERY COUNTY, MARYLAND

Description

Council encourages mixed land use developments to promote energy efficient planning through official plan policy statements and zoning ordinances.

Zoning ordinances dictate mixed land use in designated areas to minimize the travelling distance between residential, commercial, and industrial developments.

Evaluation

-A series of planning zones were designated to promote energy efficient mixed land use developments, one of which, the "transit station zone", was specifically designed to encourage the development of multi-family housing within easy walking distance of public transit. This zone also permits: churches, libraries, museums, galleries, rest homes, rooms for rent, various commercial uses such as dry cleaners, laundries, convenience stores, doctors' offices, etc.

-Few land uses are strictly prohibited. Instead, development proposals submit a compatibility study for evaluation.

Implications

-This concept is applied to existing and built-up areas rather than low density neighbourhood development.

-Promoting mixed land use neighbourhood developments to achieve energy efficiency is a long-term energy saving strategy.

-A similar strategy for Hamilton would not require increased regulation as developers are aware of the benefits gained from a degree of mixed land use in neighbourhoods. It is the location and content of the mixed land use that facilitates energy efficiency.

OTTAWA, ONTARIO

Description	Evaluation	Implications
(1980) City adopts by-law to require an "Energy Use Statement" as part of the approval process for industrial, commercial, and residential development of 25 units or more.	-The by-law promotes energy efficient development by establishing a quasi-measuring device which is available for public scrutiny hence, subtly encouraging the builder to consider energy efficiency. -The by-law does not provide the authority to approve or reject development proposals on the basis of their energy requirements; many municipalities presently reject development proposals because of water, pollution, compatibility restrictions, etc. -The by-law provides for the collection of energy data necessary for comparison purposes and the eventual creation of an energy audit system. -Depending on the energy provisions to be included in the "New Building Code", such a by-law may be redundant. -The by-law required precedent setting provincial legislation in order to be legally effective. Resistance to adoption was negligible. -A similar, although more comprehensive, concept is the energy impact assessment which is common in the United States.	-Ottawa has pioneered an excellent planning tool that should be adapted to Hamilton as a supporting by-law to PATH I and PATH II. -Faithful compliance to the intent of the by-law is of some concern, in Hamilton our incentive package will reward and hopefully encourage compliance. -With this strategy a proposed projects energy use can be compared with the energy use of alternatives such as selection of another site, utilizing passive solar heat gain or altering the street pattern. Comparing of alternatives highlights the relative magnitude of the project's energy use or the degree of its energy inefficiency.

PORT ARTHUR, TEXAS

Description	Evaluation	Implications
(1979) The City amended its subdivision code to require solar orientation to reduce exposure to sunlight of at least 80 per cent of the buildings in order to prevent summer overheating. Although mandatory in nature, the possibility of a reduction in developable lots is compensated by an accompanying reduction in road right-of-way widths (18 to 15 meters).	-This ordinance has received considerable municipal, developer, and consumer acceptance; four projects have since been approved with 86 per cent of the lots properly oriented. The ordinance is easy to adopt and implementation is checked by placing templates on the plan of subdivision. -The City discovered that its development requirement that side lot lines be perpendicular to streets had to be deleted. -Exceptions are required where the orientation is infeasible due to property size, configuration, surrounding development, existing features, circulation, servicing, or substantial monetary loss.	-A similar strategy should be incorporated in both PATH I and PATH II. In PATH I, ensure that the provision relates to building orientation primarily and lot and street orientation secondly, as this allows greater flexibility in design and more accurately assures solar access without further regulation. -The development incentive of reduced right-of-way widths should be changed to reduced pavement widths, as our latitude requires present right-of-way widths to ensure solar access.

RICHMOND, BRITISH COLUMBIA

Description	Evaluation	Implications
(1981) Richmond develops a zoning amendment which allows for an increased floor-area ratio when the proposed buildings derive more than 40% of their annual thermal requirements (heating, cooling, service water heating) or more than 30% of their annual total energy requirements from non-depletable sources (wind, solar, etc.).	-This is an excellent incentive to encourage developers to include energy efficiency in their designs; for the initial cost increase, if any, for the adoption of energy efficient measures is more than offset by the incentive to build bigger buildings.	-This strategy should be adapted and attached to the list of incentives offered to developers whose proposed projects comply with either PATH I or PATH II. -The success of this strategy in Hamilton is largely dependent on the interpretation and enforcement of the proposed Energy Use Assessment By-law.

SACREMENTO COUNTY, CALIFORNIA

Description	Evaluation	Implications
(1977) Council adopts a resolution and procedure to encourage developers to design streets and lots for solar orientation. Although the developer is not required to meet the provisions of the resolution, planning staff suggests changes to provide for better orientation. If the developer fails to comply, planning staff may recommend to planning committee that changes be made.	-The voluntary nature of the approach has had limited success. -Planning committee seldom imposes resolution on developer; as they are not legally binding: if he hasn't complied already, chances are he has no intention of doing so. -The resolution erroneously encourages lot orientation which does not necessarily facilitate proper building orientation.	-As can been seen, a Council policy coupled with a development incentive (i.e. Port Arthur's) is necessary to promote optimum building orientation in proposed developments which do not require subdivision approval. -Voluntary measures ensure only limited success; this is especially true if the approval bodies are not committed to energy efficiency.

SACREMENTO COUNTY, CALIFORNIA

Description	Evaluation	Implications
(1977) County Council requires that all new subdivision development be designed with the long axis of lots within 22.5 degress of true north, to facilitate the use of passive solar energy by assuring a southern orientation.	-The full resolution allows for generous exceptions; hence, there have been no problems with implementation. -As previously discussed, the regulation of lots by themselves does not assure souther orientation; this is true for most individual or ad hoc efforts.	-Due to the variation of housing types, densities, topography, shading, etc. it is inappropriate to adopt a similar regulation. For instance, this strategy would create huge frontages for lots on any street that approaches a north-south cardinal orientation, vastly increasing direct and embodied energy requirements of that particular neighbourhood. -To assure a southern orientation in neighbourhood design to facilitate the use of passive solar energy, Hamilton should design neighbourhoods via the proposed Solar Envelope, the Energy Use Assessment, PATH I and PATH II.

ST. PAUL, MINNESOTA

Description	Evaluation	Implications
(1981) The State has recently developed a rating system to assist builders and house buyers to assess the relative energy efficiencies of new single family houses. The method determines conservation measures and assigns points according to each measure's energy saving potential.	-The point ratings are both minus and plus, depending on the degree to which the rated measure is considered to be better or worse than the measure that is recommended. -Total scores deviate from a recommended level of energy use, indicating those homes which require greater or lesser amounts of energy. -Provision is also made in the system for evaluating the economics of the conservation measures.	-This rating system has not yet been officially adopted by the State. -Actual rating of homes to determine relative energy efficiencies is a Provincial jurisdiction. Federal and Provincial agencies are currently developing standards for rating. -This concept is similar to the study's recommended PATH approach, where conformance to energy conservation measures is not rated but incentives are granted depending on the degree of conformance.

SAN DIEGO COUNTY, CALIFORNIA

Description	Evaluation	Implications
(1978) County adopts a by-law which requires the use of solar hot water heaters in all new development in un-incorporated parts of the County in order to reduce energy use. The County, in good faith, awards developers with priority approval of their proposals.	-Planners undertook detailed surveys, evaluated several cost-benefit studies, and closely liaised with all affected parties. -Principal opposition to the by-law came from the development industry which argued that the free market would force the utilization of solar technologies; essentially, Council agreed, but felt an extra "push" was needed to hasten adoption. -This strategy is probably the strongest identified, for it requires developers to provide an energy conserving technology at substantial front-end cost which is reflected in increased housing prices. -In the San Diego area, there was already substantial use of solar water heaters, a thriving solar industry, a strong solar lobby at the State and Federal level, and the use of solar as an alternative to conventional water heaters is economically attractive.	-In Hamilton: solar hot water systems are limited to a few demonstration projects, the Canadian solar industry is but a fledgling in comparison, the active solar lobby is waning, and the economics of solar hot water heaters for residential purposes is unattractive. -Such a strategy is not recommended for Hamilton; strategies such as this will be correctly perceived as precocious unviable attempts that receive little political or legal support. -The priority approval aspect of this strategy is an excellent incentive to offer developers to conform to the "Energy Efficient Design Criteria". Although development is at a low in Hamilton, an explicit statement of Council offering to "bend-over-backwards" for well planned energy efficient development will be viewed as cost-saving incentive.

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS	1	2	3	4	5	
Legality	Illegal					●	Legal
Sophistication	Complex				●		Simple
Degree of Innovation	Innovative				●		Traditional
Cost/Benefit Analysis	Inferior			●			Superior
Experience/ Results	Negative				●		Positive
Environmental Constraints	Dissimilar				●		Similar

SIFT II

OPTION:

Montgomery

SIFT I RANK: **24**

DEVELOPMENT CONTROL	NEIGHBOURHOOD PLANNING: SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEREGULATION						
MODIFICATION	●		●		●	
NEW CONTROLS						

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS	1	2	3	4	5	
Legality	Illegal				●		Legal
Sophistication	Complex				●		Simple
Degree of Innovation	Innovative				●		Traditional
Cost/Benefit Analysis	Inferior				●		Superior
Experience/ Results	Negative				●		Positive
Environmental Constraints	Dissimilar				●		Similar

SIFT II

OPTION:

Ottawa

SIFT I RANK: **24**

DEVELOPMENT CONTROL	NEIGHBOURHOOD PLANNING: SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEREGULATION						
MODIFICATION						
NEW CONTROLS		●				

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS	1	2	3	4	5	
Legality	Illegal			●			Legal
Sophistication	Complex			●			Simple
Degree of Innovation	Innovative		●				Traditional
Cost/Benefit Analysis	Inferior				●		Superior
Experience/ Results	Negative				●		Positive
Environmental Constraints	Dissimilar	●					Similar

SIFT II

OPTION:

Port Arthur

SIFT I RANK: **17**

DEVELOPMENT CONTROL	NEIGHBOURHOOD PLANNING: SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEREGULATION						
MODIFICATION						
NEW CONTROLS		●	●			

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS	1	2	3	4	5	
Legality	Illegal					●	Legal
Sophistication	Complex			●			Simple
Degree of Innovation	Innovative				●		Traditional
Cost/Benefit Analysis	Inferior				●		Superior
Experience/ Results	Negative			●			Positive
Environmental Constraints	Dissimilar			●			Similar

SIFT II

OPTION:

Richmond

SIFT I RANK: **22**

DEVELOPMENT CONTROL	NEIGHBOURHOOD PLANNING: SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEREGULATION						
MODIFICATION		●		●		
NEW CONTROLS						

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS	1	2	3	4	5	
Legality	Illegal					●	Legal
Sophistication	Complex				●		Simple
Degree of Innovation	Innovative				●		Traditional
Cost/Benefit Analysis	Inferior		●				Superior
Experience/ Results	Negative		●				Positive
Environmental Constraints	Dissimilar		●				Similar

SIFT II

OPTION:

Sacremento

SIFT I RANK: **19**

DEVELOPMENT CONTROL	NEIGHBOURHOOD PLANNING: SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEREGULATION	●	●	●	●	●	●
MODIFICATION						
NEW CONTROLS						

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS	1	2	3	4	5	
Legality	Illegal		●				Legal
Sophistication	Complex			●			Simple
Degree of Innovation	Innovative		●				Traditional
Cost/Benefit Analysis	Inferior			●			Superior
Experience/ Results	Negative		●				Positive
Environmental Constraints	Dissimilar		●				Similar

SIFT II

OPTION:

Sacremento

SIFT I RANK: **14**

DEVELOPMENT CONTROL	NEIGHBOURHOOD PLANNING: SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEREGULATION						
MODIFICATION						
NEW CONTROLS	●				●	●

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS	1	2	3	4	5	
Legality	Illegal				●		Legal
Sophistication	Complex				●		Simple
Degree of Innovation	Innovative			●			Traditional
Cost/Benefit Analysis	Inferior				●		Superior
Experience/ Results	Negative			●			Positive
Environmental Constraints	Dissimilar				●		Similar

SIFT II

OPTION:

St. Paul

SIFT I RANK: **22**

DEVELOPMENT CONTROL	NEIGHBOURHOOD PLANNING: SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEREGULATION						
MODIFICATION		●				
NEW CONTROLS						

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS	1	2	3	4	5	
Legality	Illegal	●					Legal
Sophistication	Complex					●	Simple
Degree of Innovation	Innovative		●				Traditional
Cost/Benefit Analysis	Inferior				●		Superior
Experience/ Results	Negative				●		Positive
Environmental Constraints	Dissimilar	●					Similar

SIFT II

OPTION:

San Diego

SIFT I RANK: **17**

DEVELOPMENT CONTROL	NEIGHBOURHOOD PLANNING: SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEREGULATION						
MODIFICATION	●	●				●
NEW CONTROLS						

URBAN DOCUMENTATION CENTRE
RESEARCH UNIT FOR URBAN STUDIES
McMASTER UNIVERSITY
HAMILTON, ONTARIO

SAN DIEGO COUNTY, CALIFORNIA

Description	Evaluation	Implications
(1978) The County adopted a by-law and amended their subdivision design code to require the protection of solar access for all new subdivision lots in order to facilitate the use of solar energy systems.	-Subdivisions must be designed so that each lot will have 9 m^2 of space, raised 3 m above the ground, that receive direct sunlight during the period each day when the sun is 45° east and west of due south; buildings are then sited within this solar access zone. -Developers must show cause for not meeting requirements, e.g. topography creates extremely long shadows. -Over 8,000 single family lots have been reviewed for compliance, in only a few cases were the requirements not met. -Although compliance has been virtually assured since it is a condition of approval, the municipality has had difficulty in developing an efficient method for checking proposed plans for solar access.	-This particular solar access by-law is primarily developed for use with active solar systems; Hamilton's solar access provisions would be directed primarily at ensuring passive solar energy gain. -Hamilton's solar access strategy incorporates the principles developed in "Planning for Low Density -- A Solar Approach", as well as the design policies of this report, e.g. Solar Envelopes, Slope Orientation Synthesis, PATH I, and PATH II.

SEATTLE, WASHINGTON

Description

(1976) Seattle Trust and Savings Bank initiated a loan program allowing borrowers to negotiate an energy conservation 30-year mortgage with 20 per cent down at one quarter per cent below the market rate, compared to the conventional 30-year mortgage requiring 25 per cent down at the market rate. Further loans for home improvements, automobiles, boats, etc., are all offered at an annual percentage rate three quarters below prime.

Evaluation

-To quality for the energy mortgage loan, the property must meet at least 20 or 25 points (depending on the value of the house) out of 48 on an energy conservation list developed by the bank. The list provides, for example, five points each for adequate ceiling, wall or floor insulation, five points for storm windows or double glazing or one point for plastic sheeting over windows, one point for fireplace damper integrity, and five points for solar heating.

No maximum or minimum amounts are set. Developers can pre-qualify entire subdivisions by adhering to the bank's energy conservation criteria.

The energy home improvement loans also depend on the home's qualifying for at least 25 points on the list, while the auto loans require that the car purchased have an Environmental Protection Agency rating of at least 25 miles a gallon on the highway. Boat loans qualify if the vessel is wind-powered or meets the bank's standards for engine efficiency.

Implications

-This financing concept has had considerable success and should be adopted in principle and promoted by the City.

-This concept taps the expertise, procedures and resources of existing financial institutions and does not rely on the creation of untried lending schemes, increased government regulation, or require taxpayer subsidized loans.

-Banks and trust companies benefit through increased market exposure and expansion into the mortgage and consumer loan sector where returns are better than for other similar term investments.

-The reduced prime and down payment are justified by the fact that the home is less of a liability due to lower operating costs.

-Development risk is not increased as developers may now incorporate energy saving features generally at a higher front end cost that is not reflected by increased down and monthly payments.

-Developer arranged mortgages facilitate purchase and further decrease development risk; development risk is directly proportionate to prices.

-This concept is a direct purchase incentive to home buyers who desire the benefits of energy efficient dwellings, for they are not penalized by increased down payments and are rewarded by a reduced prime on subsequent loans.

SIOUX CITY, IOWA

Description	Evaluation	Implications
(1976) Zoning provisions contain development incentives, where developers are given bonuses if they comply with local development policies such as energy efficiency.	-This approach to energy planning relies on private marketing decisions, rather than enforced regulation to implement a municipality's development policies. Regulation is not increased. Both the municipality and developer benefit.	-A list of development incentives prepared as a part of this study should be adopted and attached to the "Energy Efficient Design Criteria" (PATH I), and the "Energy Efficient Performance Standard" (PATH II). Development incentives may be applied, at the discretion of Council, to a proposed plan of neighbourhood development, depending on the degree of conformity to either PATH I or PATH II.

WINDSOR, CONNECTICUT

Description	Evaluation	Implications
(1975) Windsor offers density bonuses and reduced parking standards to convertors of residential dwellings to office and multi-family, if the projects are near shopping, bicycle/foot paths, and public transit. The town also requires that all new neighbourhood development be located within 1/2 mile of schools and 1 mile of public transit. Both these measures are intended to reduce the use of private automobiles, promote mixed land use, increase densities, and facilitate the use of public transit.	-The requirements and incentives are contained in the zoning by-law. -The by-law has been very effective in promoting energy efficient development without creating a burden on the planning/approval process. -Both Windsor's and Boulder's strategies relate the location of new development/re-development to its proximity to existing development. In this respect they strongly encourage "infilling" and subtly promote energy efficiency through incentives, rather than increased regulation. When a strategy promises only limited energy savings, but adds to government costs or the price of development, it should be given a low priority.	-Council should adopt a list of development incentives which may then be granted according to the degree of conformity to either the "Energy Efficient Design Criteria" (PATH I), or the "Energy Efficient Performance Standard" (PATH II).

WOODSTOCK, ONTARIO

Description

(1980) Woodstock was the first Ontario municipality to review its zoning by-law to ensure maximum energy efficiency in new developments. As part of an overall review to update its zoning by-law, the study aims were to ensure that the zoning by-law does not prohibit or discourage energy efficient development, and to recommend policies which will facilitate such developments. The specific topics that the study was asked to cover included the effects of the zoning by-law on solar access, allowances for structures such as windmills and solar collectors, and parking standards.

Evaluation

-It is suggested that solar access be made a condition of subdivision agreements, and that site plans be required to illustrate shadows cast at various times of the year. Density bonuses could be offered for compliance.

-Municipalities could ensure solar access through by-law provisions that require:

1) east-west oriented streets;

2) a two storey maximum building height in residential areas;

3) nine metre rear yards.

-Other suggested by-law changes related to solar access were:

1) greenhouses, vestibules, and enclosed porches should be permitted as yard encroachments;

2) revisions could be made to yard setbacks to allow for key lotting;

3) heights of accessory buildings should be limited to 10 feet, to prevent overshadowing of buildings located to the north.

-Solar access maps also were prepared by consultants and indicate areas most suited to solar access protection.

-Recommendations were made to reduce the size of parking aisles and stalls to conform to C.M.H.C. guidelines.

Implications

-A comprehensive review of the zoning by-law to examine those aspects which mitigate against energy efficiency is a valuable although monumental task. The cost of such a review dictates that it only be performed as part of a whole zoning by-law update.

-Hamilton should adopt the strategy that solar access be made a condition of subdivision agreements, and that site plans be required to illustrate shadow patterns for various times and dates. The degree of shading should not affect approval at this time.

-Many of the Woodstock recommendations dealing with solar access are contained in the City of Hamilton's report, Planning for Low Density - A Solar Approach, and developed to greater sophistication in this study's proposed Solar Envelopes (page 37).

-As a condition of draft plan of subdivision and site plan approval, the site potential for solar energy utilization should be indicated through slope analysis (page 27).

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS						
		1	2	3	4	5	
Legality	Illegal				●		Legal
Sophistication	Complex	●					Simple
Degree of Innovation	Innovative		●				Traditional
Cost/Benefit Analysis	Inferior				●		Superior
Experience/ Results	Negative				●		Positive
Environmental Constraints	Dissimilar		●				Similar

SIFT II

OPTION:
San Diego

SIFT I RANK: 1

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION						
	MODIFICATION						
	NEW CONTROLS			●			●

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS						
		1	2	3	4	5	
Legality	Illegal					●	Legal
Sophistication	Complex				●		Simple
Degree of Innovation	Innovative		●				Traditional
Cost/Benefit Analysis	Inferior				●		Superior
Experience/ Results	Negative				●		Positive
Environmental Constraints	Dissimilar			●			Similar

SIFT II

OPTION:
Seattle

SIFT I RANK: 22

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION						
	MODIFICATION		●				
	NEW CONTROLS						

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS						
		1	2	3	4	5	
Legality	Illegal					●	Legal
Sophistication	Complex					●	Simple
Degree of Innovation	Innovative				●		Traditional
Cost/Benefit Analysis	Inferior				●		Superior
Experience/ Results	Negative				●		Positive
Environmental Constraints	Dissimilar		●				Similar

SIFT II

OPTION:
Sioux City

SIFT I RANK: 24

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION						
	MODIFICATION	●	●	●	●	●	●
	NEW CONTROLS						

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS						
		1	2	3	4	5	
Legality	Illegal				●		Legal
Sophistication	Complex				●		Simple
Degree of Innovation	Innovative			●			Traditional
Cost/Benefit Analysis	Inferior			●			Superior
Experience/ Results	Negative				●		Positive
Environmental Constraints	Dissimilar			●			Similar

SIFT II

OPTION:
Windsor

SIFT I RANK: 21

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION						
	MODIFICATION			●		●	●
	NEW CONTROLS						

SIFT I

OPTION:

MAJOR EVALUATION CRITERIA	SCALE OF IMPLEMENTATION EFFECTIVENESS						
		1	2	3	4	5	
Legality	Illegal					●	Legal
Sophistication	Complex			●			Simple
Degree of Innovation	Innovative				●		Traditional
Cost/Benefit Analysis	Inferior			●			Superior
Experience/ Results	Negative		●				Positive
Environmental Constraints	Dissimilar				●		Similar

SIFT II

OPTION:
Woodstock

SIFT I RANK: 21

		NEIGHBOURHOOD PLANNING					
		SITE SELECTION	BUILDING DESIGN	LAND USE	DENSITY	TRANSPORTATION	DEVELOPMENT STANDARDS
DEVELOPMENT CONTROL	DEREGULATION	●	●	●	●	●	●
	MODIFICATION						
	NEW CONTROLS						

Energy Efficient Design Criteria Checklist

Appendix D

The information presented in this appendix is intended to provide developers and municipal administrators with practical guidelines for the adoption of energy efficient measures in planning, designing, and constructing neighbourhood development. Most, if not all, of these guidelines may be incorporated in the various land use control strategies described in Part Five.

Aside from its educational value, developers must complete the Checklist in order to be considered for PATH I incentives. Developer's desiring incentives, but opting for the performance approach of PATH II, may use the guidelines to facilitate attainment of the energy standards.

Municipal administrators would use the Checklist to determine a particular development proposal's degree of conformance to the guidelines; work with the developer to suggest energy saving improvements; and establish a basis for awarding incentives. As noted (page ....), the potential energy savings of some developments will not warrant the granting of incentives. In such instances the checklist could be used for design consideration only or become requirements for approval.

The Checklist is divided into the following headings:

i) Site Selection
ii) Site Preparation
iii) Subdivision Design
iv) Building Design
v) Construction
vi) Landscaping

SITE SELECTION

- Select a site which:
  - i) Possesses a high air quality to enhance natural ventilation.
  - ii) The longer axis of the site is oriented in a general east-west direction.
  - iii) The site possesses a general south-facing slope, or extensive flat areas of less than five per cent.
- Analyze micro-climate conditions, noting monthly air temperature fluctuation, hours of sunshine, heating and cooling degree days, average precipitation and wind speed/frequency/direction (Ecochart Analysis).
- To facilitate solar access, determine a composite shadow plan (December 21 to June 21) for all existing on-site and adjacent natural and man-made features.
- Analyze existing topography, noting highest and lowest points, characteristics of vegetation, water bodies, as well as orientation and angles (steepness) of all slopes.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

SITE PREPARATION

- Minimize the operation of equipment for grading, demolition, clearance of existing natural and man-made features.
- Stockpile cleared trees for firewood when practical.
- Stockpile topsoil for landscaping.
- Utilize natural on-site drainage techniques for storm water management (e.g. swales, percolation basins, etc.).
- Improve the topography of the site to facilitate energy efficiency (e.g. accentuate south facing slopes, conserve mature trees, etc.).

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

SUBDIVISION DESIGN

- Design lots that are wider and shallower, elongated in an east-west direction, maintaining the total lot area and useable open space, but increasing southern exposure.

- Set uniform rear yard setbacks for north entry units and uniform front yard setbacks for units with a south entry.

- Provide wide sideyards on north-south streets to avoid shadowing problems between adjacent buildings.

- Allow for slightly greater frontage on north-south streets to permit sun penetration into second story windows and to minimize the blockage of sun on the south face by garages.

- Utilize zero lot line type development to facilitate optimum placement of structure on lot.

- Where houses must be oriented east-west on a north-south street:
  - i) angle lots so that major facade faces south
  - ii) angle east and west facing windows to the south

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

iii) place windows on east and west facades to take advantage of solar gain

iv) use unusual lot configurations to maximize southern exposure

v) provide southern exposure for the second storey.

- Maximize the use of lots on south facing slopes by placing structures closer together without interfering with solar access.
- Angle lots and/or structures to provide south-east to south-west exposure. An orientation with a 15 degree variance off due south is a general rule of thumb.
- Maximize compact designs as they are more efficient than sprawling ones.
- Maximize the use of common walls, floors, and ceilings. Attached units are more energy efficient than detached units because there are fewer exterior walls through which to lose heat.
- Locate medium and high density development in mixed land use areas in high activity centres and nodes, or as buffers along major transportation routes.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

- Utilize cluster type development.

- Utilize centralized heating systems for medium and high density land uses.

- Design bicycle paths and walkways which are segregated from vehicular traffic, protected from cold winds and shaded from summer sun, and which offer residents a convenient alternative to road transport.

- Ensure the site has convenient access to, or the proposed plan provides for, the necessary services and facilities with the following maximum distance criteria:

Developed Neighbourhood Park	5 minutes
Public Transit Stop	5 minutes
Schools	5 minutes
Local Shopping Facilities	5 minutes
Library	5 minutes
Day Care Centre	5 minutes
Recreational Facilities	5 minutes
Fire, Police, Ambulance Response	4 minutes.

- Design local and minor local streets in an east-west orientation with a maximum variance of 15 degress off due south.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

- Minimize local and minor local street pavement widths.
- Orient dwellings on lots to consider micro-climate effects such as wind, since relatively large amounts of heat are lost by transmission and infiltration.
- Do not squander the potential of southern orientation by using a dwelling not designed to take advantage of passive solar gain.
- Utilize open spaces, hazard lands, environmentally sensitive areas, and utility corridors to buffer residential areas and protect solar access.
- Ensure that the greatest possible number of buildings receives 100 per cent south wall solar access between 9:00 and 15:00 on December 21.
- Use slopes and earth berms to partially bury building in order to reduce heat loss.
- Utilize the most efficient road, water, sewer, and utility infrastructure design.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

- Use ponds, water fountains, grass and tree covered open spaces, etc. to reduce ambient outdoor air temperature around buildings.

- Use snow and earth berming to deflect wind, snow, and noise.

- Do not situate buildings in cold air sinks.

- Place buildings to effectively direct winter winds away from buildings and direct summer breezes into them.

- Locate taller buildings to the north of the site and perpendicular to winter winds.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

BUILDING DESIGN

- Locate bedrooms on the eastern sides of homes as in summer they have the coolest evening temperatures and receive morning sunshine year-round.
- Locate activities and spaces which are heat producing, of low occupancy, or require low lighting on the north sides of buildings.
- Locate activity and living areas on the south sides of buildings as they are naturally warmer.
- Optimally align partitions of a building along a north-south axis to facilitate convection and radiant heat transfer.
- Design overhangs to shade windows in summer and permit the entry of sun in winter.
- Minimize heated area by not heating garage, storge, and other similar areas. Design homes with open floor plans that have minimal or no hall areas.
- Avoid inefficient rambling shapes that increase volume and surface area to useable floor area ratios.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

- Draw composite shadow patterns (June/December, 09:00 - 15:00) for proposed building(s).

- Increase density (less gross floor area per person) to reduce the overall size of the building and yearly energy consumption per capita.

- Locate screening in the form of walls or the placement of garage or exterior storage rooms on the north and west sides to act as buffers against winds.

- Incorporate massive masonry elements such as floor slabs and fireplace enclosures which act as heat sinks absorbing sunlight passing through southern windows during the day and radiating heat into the living space at night.

- Place furnace and fireplace chimneys in an internal central location to maximize heat transfer from these sources.

- Locate hot water heaters closest to points of use such as kitchens and bathrooms in order to minimize the length of the hot water pipe.

- Locate chimneys and fireplaces on interior walls to allow radiation of heat within the building and to isolate it from exterior wall heat losses - design fireplaces using glass doors, fresh air intakes and heat exchangers.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

- Maximize rectangular floor plans to provide optimal surface to volume ratio that reduces detrimental heat losses and gains, as well as reducing construction costs.

- Use sunshine hours and radiation data for design of passive or active solar system.

- Design building with minimum north exposure.

- Orient the length of the building to the south to optimize solar gains in winter and reduce summer cooling.

- Locate more and larger windows and other openings in the building envelope on the south facade and fewer and smaller windows on the north, east and west facades.

- Use building configuration and wall arrangement (horizontal and vertical walls) to provide self shading and wind breaks (based on wind charts or actual model testing).

- Where applicable, increase heat gain due to solar radiation on walls and roofs by using a dark-coloured finish having a high absorbancy.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

- Use reflective surfaces such as sloping white ceilings to enhance the effect of natural lighting and increase the yearly energy saved.

- Use corridors as heat transfer buffers and locate against external walls.

- Locate building entrances and windows on downwind side and provide wind break.

- Provide all entrances with airlocks.

- Where sloping roofs are used, face them to south for greatest heat gain benefit in the wintertime.

- Adjust the configuration of the building to allow natural cross ventilation through occupied spaces.

- Ensure that garage placement does not result in a loss of south wall solar access.

- For lots on the north side of east-west streets, locate the garage ahead of the house toward the street and set the house back on the lot to the rear of yard so that the garage does not consume part of the southern wall.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

- Slope the roof of the garage to reduce the shadow cast on the south facing windows and to reflect the sun's rays onto south facing walls in the winter.

- Eliminate mechanical air conditioning by using physical devices to manipulate and cool.

- Design buildings with a maximum pitched roof and minimum wall area on the windward side of buildings.

- Provide shade by trellises with deciduous vines or other architectural devices (awnings, overhangs, etc.).

- Increase densities and reduce exterior exposure by consolidating units (e.g. duplexes, row housing, etc.).

- Design houses on north side of street with an entry and outdoor living space to the south; design houses on the south side of a street with an entry on the north and outdoor living area on the south.

- Walls, fences, buildings, etc. serve to provide wind protection, increased ventilation, shade, reflective surfaces, heat sinks, and generally to modify the micro-climate.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

- Incorporate the atrium design in buildings.
- Concentrate glazed areas on the south side of buildings.
- Service all dwellings with natural gas where practical.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

CONSTRUCTION

- To reduce heat loss from windows, consider one or more of the following:
  - a) Use minimum ratio of window area to wall area.
  - b) Use double glazing.
  - c) Use triple glazing.
  - d) Use double reflective glazing.
  - e) Use minimum percentage of the double glazing on the north wall.
  - f) Manipulate east and west walls so that windows face south.
  - g) Allow direct sun on windows September through March.
  - h) Avoid window frames that form a thermal bridge.

- Use electric ignition in place of gas pilots for gas burners.

- Use natural illumination in areas where effective when a net energy conservation gain is possible vis-a-vis heating and cooling loads.

- Provide exterior reflectors at windows for more effective internal illumination.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

- Locate insulation for walls and roofs and floors over garages at the exterior surface.
- Insulation:
  - Minimum - Building Code
  - Optional - Calculation based on whole year temperature profile.
- Insulate basement and crawling spaces.
- Construct exterior walls, roof and floors with high thermal mass.
- Place vapour barrier on the warm side of insulation).
- Ensure airtight design and construction of doors, windows, and other openings.
- Avoid cracks and joints in building construction to reduce infiltration.
- Avoid thermal bridges through the exterior surfaces.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

- Compute the heating and cooling load based on heating/cooling degree-day or some other method.
- Determine lifestyle costing.
- Provide vestibules and airlock with self-closing weather-stripped doors to isolate them from the stairwells and elevator shafts.
- Seal all vertical shafts.
- Do not heat parking garages.
- To take advantage of natural daylight within the building and reduce electrical energy consumption, consider the following:
  a) Increase window size but do not exceed the point where yearly energy consumption, due to heat gains and losses, exceeds the saving made by using natural light.
  b) Locate windows high in wall to increase reflection from ceiling, but reduce glare effect on occupants.
  c) Control glare with translucent draperies.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

d) Provide exterior shades that eliminate direct sunlight, but reflect light into occupied spaces.

- Use permanently sealed windows to reduce infiltration.

- Where operable windows are desirable, use windows that close against a sealing gasket.

- For natural ventilation, consider the following:

  a) Adjust building orientation and configuration to take advantage of prevailing winds.

  b) Use operable windows to control ingress and egress of air through the building.

  c) Use stack effect in vertical shafts, stairwells, etc., to promote natural air flow through the building.

- If electric heating is contemplated, consider the use of heat pumps in place of direct resistance heating; by comparison they consume one third of the energy per unit output.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

- Consider a selective lighting system in regard to the following:
  - a) Reduce the wattage required for each specific task by review of user needs and method of providing illumination.
  - b) Illuminate tasks with fixtures built into furniture and maintain low intensity lighting elsewhere.
  - c) Provide timers to automatically turn off lights and vents in remote or little used areas (laundry and bathroom).
- Consider the use of light colours for walls, floors, and ceilings to increase reflectance, but avoid specular reflections.
- Lower the ceilings or mounting height of luminaires to increase level of illumination with less wattage.
- Consider use of greater contrast between tasks and background lighting, such as 8 to 1 and 10 to 1.
- Use lamps with higher lumens per watt input.
- Avoid decorative flood lighting.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

- Direct exterior security lighting at entrances and avoid illuminating large areas adjacent to building.
- Consider switches activated by intruder devices rather than permanently lit security lighting.
- If already available, use street lighting for security purposes.
- Use deeper studs to increase the wall cavity for additional insulation.
- Substitute rigid insulation materials in place of sheathing to achieve higher and more uniform R values without increasing wall thickness.
- Use higher density insulation batts within standard wall studding.
- Insulate and weatherstrip the access hatch to the actic.
- Use a ratio of east-west length to north-south length of slightly greater than 1:1 to 2:1.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

- Build moderate size buildings since larger scale ones take longer to cool down and heat up due to indoor-outdoor temperature differences.

- Do not construct spaces which project outward from the general perimeter of a building as they exhibit high surface area to volume and are therefore thermally undesirable.

- Consider switches activated by intruder devices rather than permanently lit security lighting.

- If already available, use street lighting for security purposes.

- Consider the use of a total energy system integrated with all other systems.

- Use heat pumps in place of electric resistance heating and take advantage of the favourable coefficient of performance.

- Check energy efficiency of all applicances.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

LANDSCAPING

	GUIDELINE				
	FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE
- Deciduous trees are sited to provide shading in summer and solar access in winter.					
- Species and size of deciduous trees are analyzed to account for the bare branch shading effect.					
- Coniferous trees of substantial size and extent are used as shelter belts to deflect and reduce winter winds.					
- Coniferous trees are sited to ensure solar access to buildings.					
- Vegetation is used to channel and enhance summer breezes.					
- Vines are used on brick, stone, and concrete walls.					
- Grass, plants, or other ground cover used against buildings rather than pavement.					
- Exterior walls and/or roof are covered with earth and plantings to reduce heat transmission.					

- Outside shading devices are used to shade major window areas from 10:00 a.m. to 5:00 p.m. during summer months.

- Coniferous trees of substantial size and extent (two to three rows in staggered formation) are used as shelter belts to deflect and reduce winter winds.

- Coniferous trees are located so as not to block solar access to buildings; planted up-wind at a distance of 1.5 to 2.0 times the building height.

- Ground cover is used instead of pavement on ground surfaces adjacent to south and west walls to reduce glare and reflected radiation.

- Trees to be used for street trees or for shading of parking areas should have the following characteristics:

  i) deciduous

  ii) cover at least 50 per cent of the paved area at maturity

  iii) be long lived (over 60 years)

  iv) grow high and spread wide naturally

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

v) do well in urban environments - tolerant

vi) require little maintenance

- Plant additional trees on the lots with the type and size of tree to be submitted to the municipality for approval prior to planting.

- Require landscaping about a building to be cup-shaped, opening toward the south.

- Require a landscaping plan which details type, height, location, and shadow projection for all landscaped features.

GUIDELINE				
FULLY SATISFIED	MOSTLY SATISFIED	PARTIALLY SATISFIED	NOT SATISFIED	NOT APPLICABLE

Shadow Templates

Appendix E

The shadow template set is the simplest tool for determining the size and direction of shadows cast by any natural or man-made object.

With no section drawing required, the set can be used for:

1. The design and evaluation of development proposals, plans, landscape and architectural designs, and even interior layouts. Shadow templates make possible the quick determination of shadows from the nearest hour after sunrise to the nearest hour before sunset on the 21st day of every month.

   Formula: Shadow Length = Height x Coefficient

2. A determination of the height of the object, if the length of the shadow is stipulated. Thus, we can arrive at the permissible height of adjacent structures, trees, the height and size of an overhang, sunscreen, and also arrive at the desirable size and shape of windows, skylights and other openings and architectural features.

   Formula: Height = Shadow Length   Coefficient

USE OF SHADOW TEMPLATES

TASK I:

FIND THE SHADOW OF A 3Metre HIGH POLE AT 09.00; 10.00; 11.00; 12.00; 13.00; 14.00; AND 15.00 HOURS.
DATE: DECEMBER 21 ST.
LATITUDE: 43 DEGREES NORTH (HAMILTON)
SLOPE: 0% (FLAT LAND)

STEP I:

SELECT THE CORRESPONDING TEMPLATE (I.E. DECEMBER 21)

STEP 2:

SEE FIGURE 2.

STEP 3:

SEE FIGURE 3.

STEP 4:

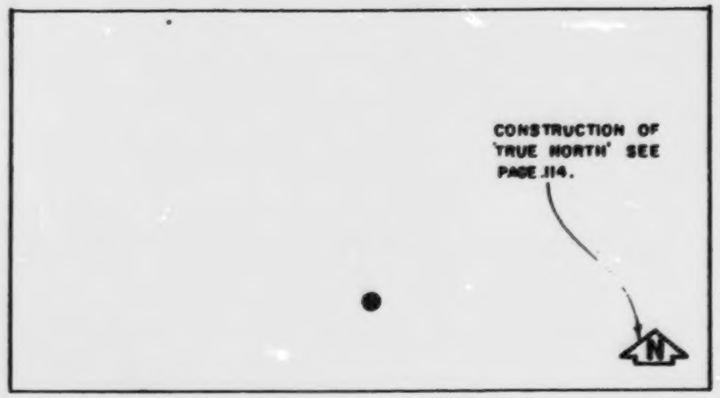
MULTIPLY THE HEIGHT OF THE OBJECT BY THE APPROPRIATE COEFFICIENT ON THE TEMPLATE PROVIDED FOR EACH TIME PERIOD; FOR EXAMPLE:
AT 09.00 HOURS SHADOW OF OBJECT EQUALS HEIGHT OF OBJECT TIMES COEFFICIENT, (3mx 4.828 = 14.48m)
THEREFORE, 14.48 IS THE LENGTH OF THE SHADOW CREATED BY THE OBJECT AT THAT PARTICULAR TIME (09.00 HOURS);
- REPEAT THIS PROCESS FOR ALL OTHER TIMES.

STEP 5:

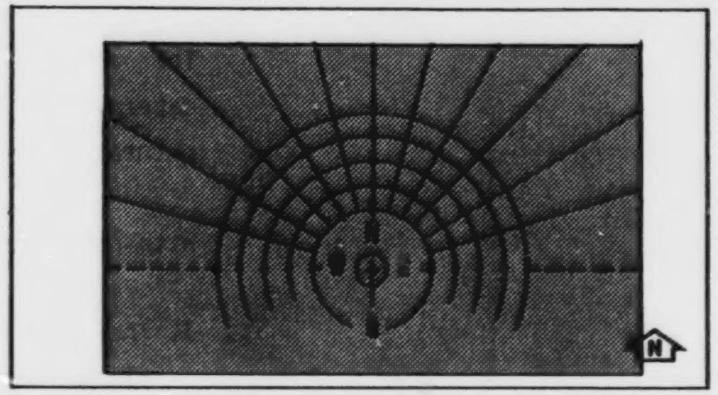
REMOVE THE TEMPLATE.

STEP 6:

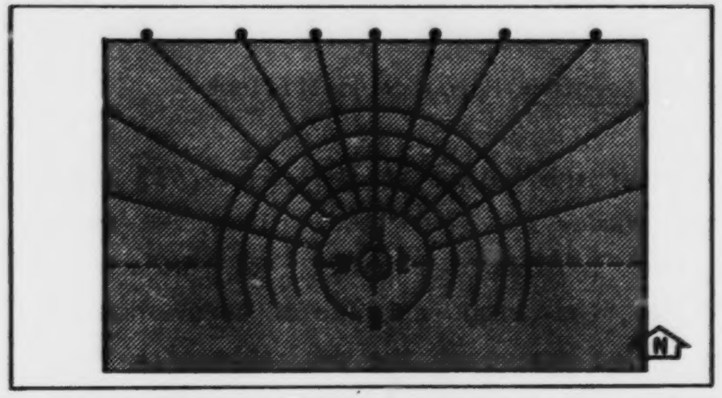
SEE FIGURE 4.



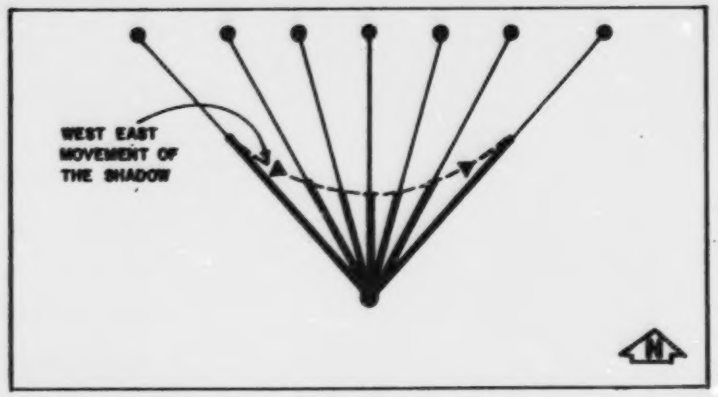
1. PLAN OF 3metre POLE.



2. OVERLAY THE CENTRE OF THE CROSS IN THE CIRCLE ON THE CORRESPONDING TEMPLATE ONTO THE CENTRE OF THE OBJECT (I.E. 3 metre POLE). MAKE SURE THE POSITION OF THE NORTH POINT OF THE PLAN COINCIDES WITH THE NORTH POINT OF THE TEMPLATE.



3. TO TRANSFER ALL SEVEN LINES INDICATED ON THE TEMPLATE (UPPER EDGE OF ACETATE) ONTO THE PLAN THAT THE OBJECT (I.E. 3 metre POLE) IS DRAWN ON, MAKE A MARK BETWEEN THE EDGE OF TEMPLATE AT THE APPROPRIATE LINE AND THE PLAN OBJECT IS DRAWN ON.



4. JOIN ALL SEVEN LINES ON THE PLAN TO THE CENTRE OF THE OBJECT AND MARK CALCULATED SHADOW LENGTHS ON THE RESPECTIVE LINES I.E. 09·00 HOURS ·· 14.48m, 10·00 HOURS ·· 9.23m, 11·00 HOURS ·· 7.39m, 12·00 HOURS ·· 6.86m, 13·00 HOURS ·· 7.39m, 14·00 HOURS ·· 9.23m, AND 15·00 HOURS ·· 14.48m.

CONSTRUCTION OF SHADOWS AT FOUR NOMINAL SLOPES
(NORTHERN, EASTERN, WESTERN AND SOUTHERN)

TASK:

CONSTRUCT A COMPOSITE SHADOW OF A 10 METERS HIGH POLE AT 0600 - 1800 HRS.

DATE: JUNE 21 ST.

LATITUDE: 43° N. (HAMILTON)

SLOPE: 5% NORTH

SOLUTION

STEP 1 SELECT CORRESPONDING TEMPLATE (JUNE 21 ST., 43° N. LATITUDE)

STEP 2 OVERLAY THE CENTRE OF TEMPLATE ONTO THE CENTRE OF THE OBJECT (10 METERS POLE)

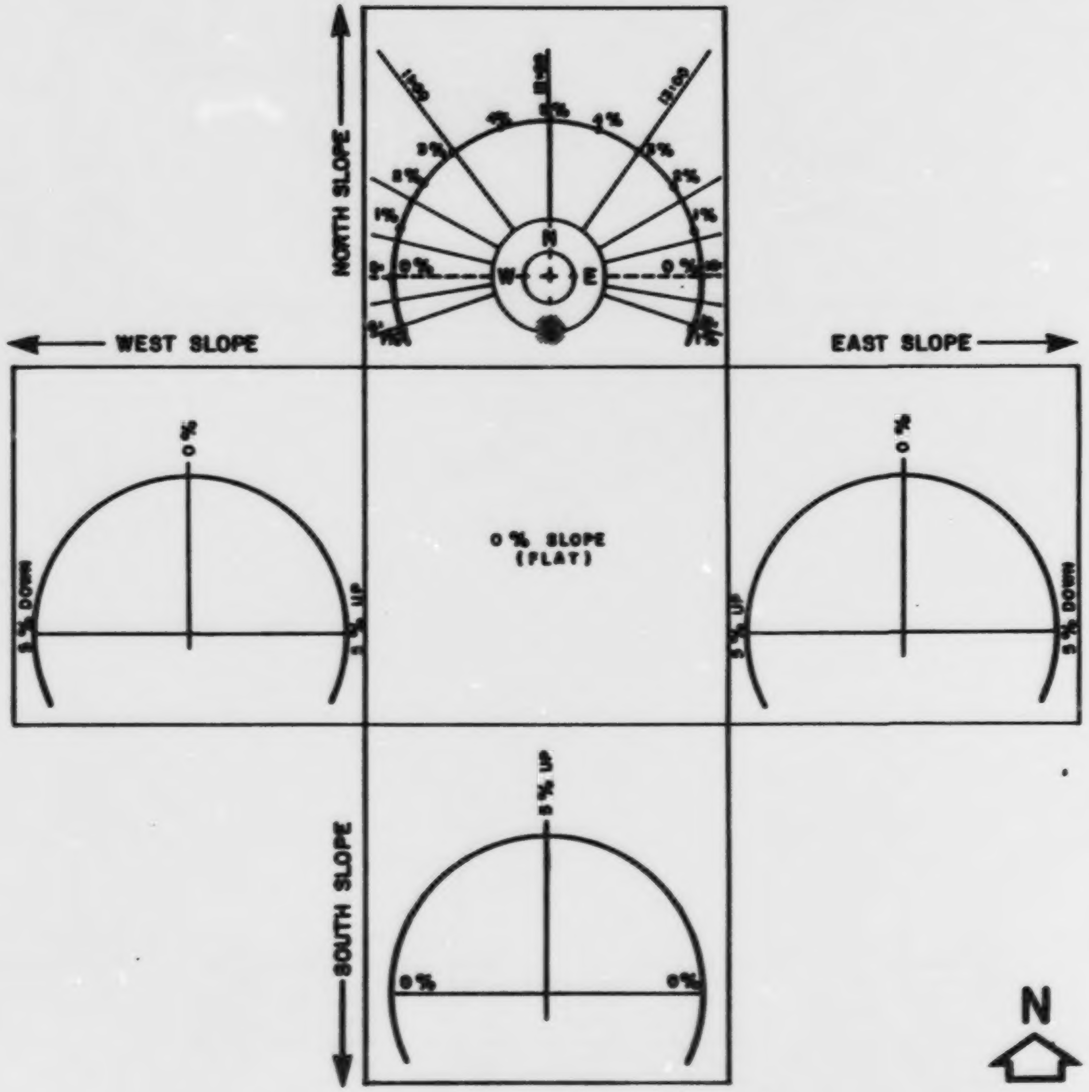
STEP 3 TRANSFER TIME/AZIMUTH LINES ON THE PLAN.

STEP 4 MULTIPLY THE HEIGHT OF THE OBJECT (10 METERS) BY A COEFICIENT. NOTE EACH HOUR (TIME/AZIMUTH DIRECTION) REQUIRES DIFFERENT COEFICIENT.

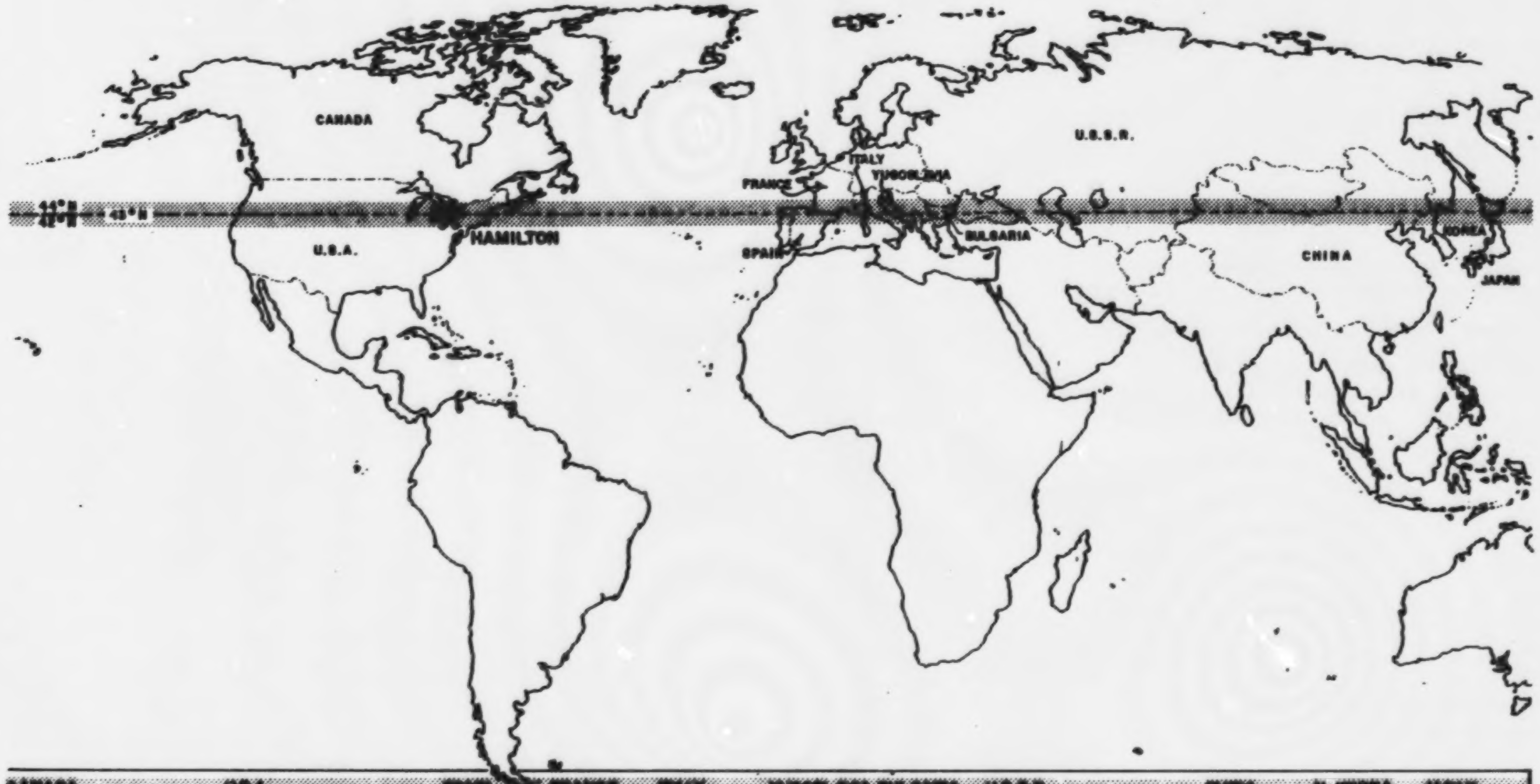
FOR EXAMPLE:

TIME	SLOPE %	COEF.
1200	5% DOWN	0·363
1100 1300	3% DOWN	0·432
0800 1600	0% (FLAT)	1·306
0600 1800	1% UP	3·399

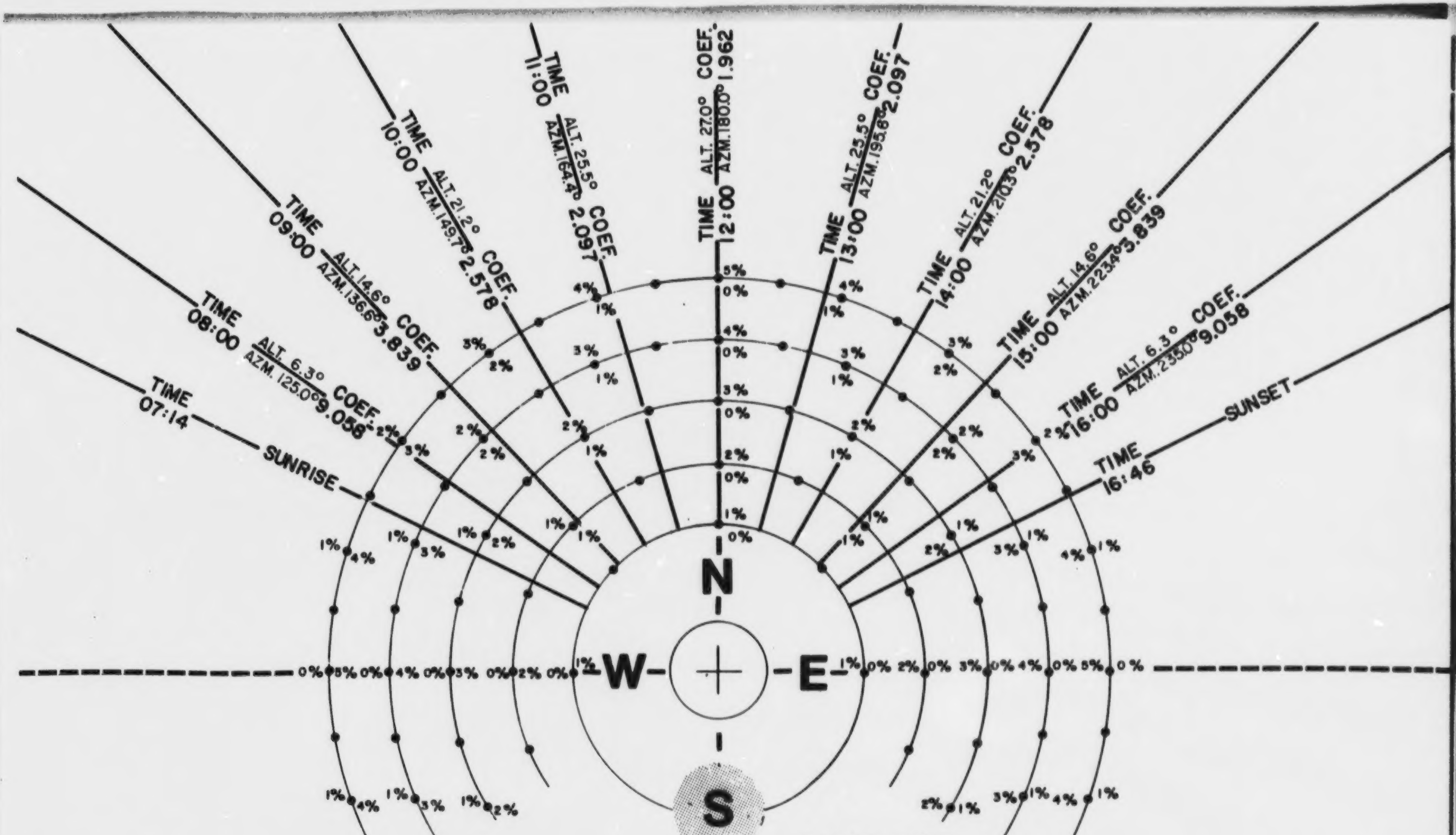
STEP 5 CONNECT ENDS OF CASTED SHADOWS AS IN PREVIOUS TASKS.


NORTH SLOPE
12:00
13:00
5%
3%
1%
0%
N
W
E
WEST SLOPE
EAST SLOPE
0%
5% DOWN
5% UP
0% SLOPE
(FLAT)
5% UP
5% DOWN
SOUTH SLOPE
5% UP
0%
0%
N

HAMILTON SHADOW TEMPLATE SET IS APPLICABLE FOR ANY CITY LOCATED BETWEEN 42°N AND 44°N LATITUDE



CANADA		U.S.A.		SPAIN	FRANCE	ITALY	YUGOSLAVIA	BULGARIA	U.S.S.R.		CHINA	N. KOREA	JAPAN
HAMILTON	GUELPH	BOSTON	DETROIT	BILBAO	NICE	ROME	SPLIT	SOFIJA	GROZNYJ	USSURIJSK	SHENYANG	CH'ONGJIN	SAPPORO
TORONTO	KITCHENER	CAMBRIDGE	WARREN	LA CORUNA	TOULOUSE	FIRENZE	SARAJEVO	RUSE	FRUNZE	SUCHUMI	FUSHUN		ASAHIKAWA
ETOBICOKE	WATERLOO	WORCESTER	LIVONIA	VIGO	MARSEILLE	FOLIGNO		VARNA	ALMA-ATTA	POTI	CHANGCHUN		OTARU
NORTH YORK	CAMBRIDGE	SPRINGFIELD	DEARBORN	OVIEDO	MONTPELLIER	LIVORNO			VLADIVOSTOK	MOZDOK	JILIN		MURORAN
SCARBOROUGH	BRANTFORD	ROCHESTER	FLINT	GIJON	NIMES	PRATO			SOCI	GORI	YINING		HAKODATE
NIAGARA FALLS	LONDON	BUFFALO	LANSING	SANTANDER	TOULON				KUTAISI	KIZL'AR	WULUMUQI		OBIHIRO
ST. CATHARINES	ST. THOMAS	ALBANY	GRAND RAPIDS	SAN SEBASTIAN					NAL'CIK		FUXINSHI		KUSHIRO
WELLAND	CHATHAM	UTICA	CHICAGO	PAMPLONA					ORDZONIKIDZE		SIPING		
BURLINGTON	WINDSOR	SYRACUSE	ROCKFORD						MACHACKALA		LIAOYUAN		
OAKVILLE	SARNIA	NIAGARA FALLS	MILWAUKEE						CIMKENT				
BRAMPTON		ERIE	MADISON						DZAMBUL				


TIME 07:14
SUNRISE
TIME 08:00 ALT. 6.3° AZM. 125.0° COEF. 9.058
TIME 09:00 ALT. 14.6° AZM. 136.6° COEF. 3.839
TIME 10:00 ALT. 21.2° AZM. 149.7° COEF. 2.578
TIME 11:00 ALT. 25.5° AZM. 164.4° COEF. 2.097
TIME 12:00 ALT. 27.0° AZM. 180.0° COEF. 1.962
TIME 13:00 ALT. 25.5° AZM. 195.6° COEF. 2.097
TIME 14:00 ALT. 21.2° AZM. 210.3° COEF. 2.578
TIME 15:00 ALT. 14.6° AZM. 223.4° COEF. 3.839
TIME 16:00 ALT. 6.3° AZM. 235.0° COEF. 9.058
TIME 16:46
SUNSET
N
W
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S
0%
1%
2%
3%
4%
5%

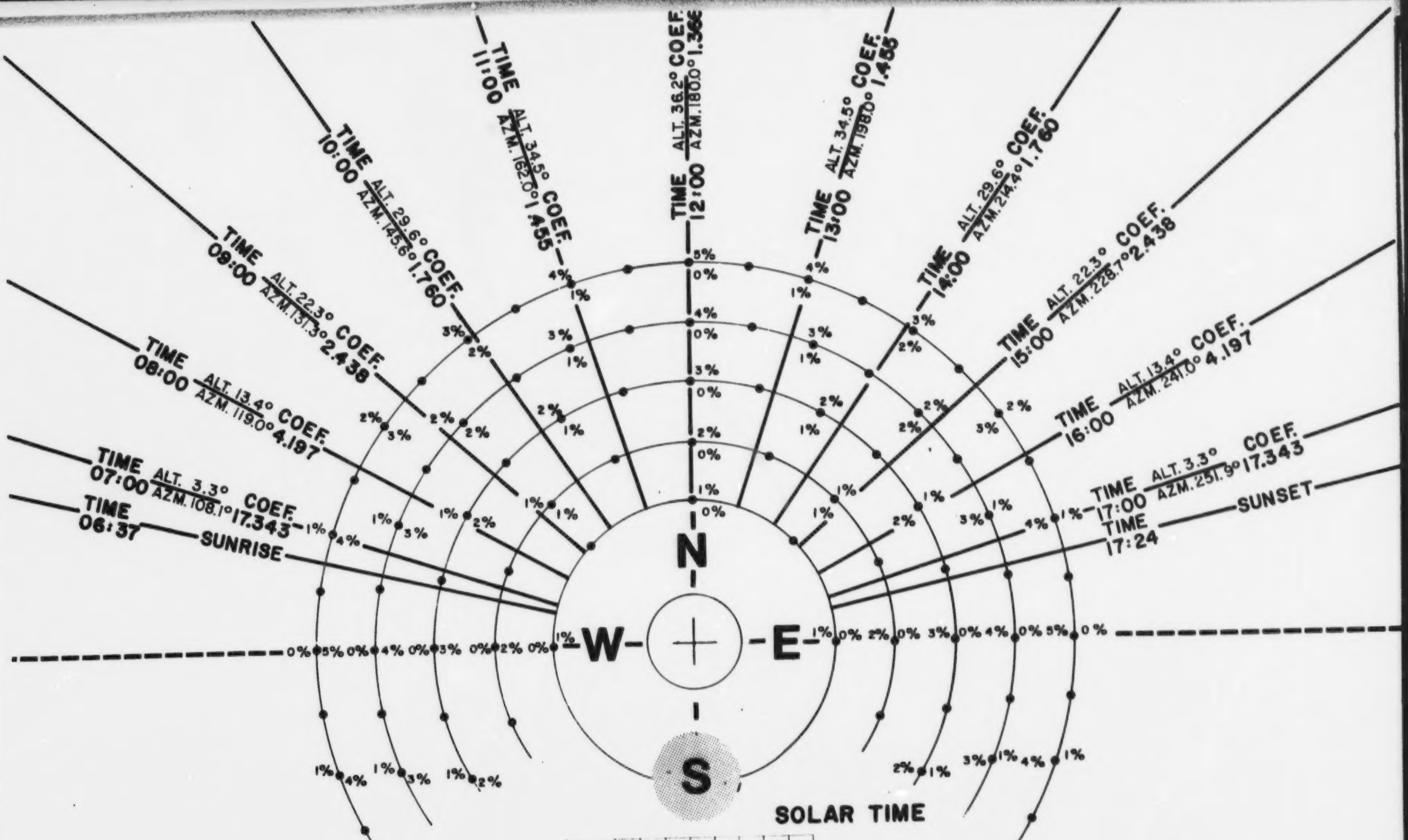
SOLAR TIME

SLOPE IN % AND DIRECTION		05:00 19:00 HOURS	06:00 18:00 HOURS	07:00 17:00 HOURS	08:00 16:00 HOURS	09:00 15:00 HOURS	10:00 14:00 HOURS	11:00 13:00 HOURS	12:00 HOURS
1%	UP				8.326	3.697	2.516	2.053	1.925
	DOWN				9.958	3.992	2.646	2.141	2.001
2%	UP				7.670	3.566	2.452	2.012	[illegible]
	DOWN				11.098	4.158	2.718	[illegible]	2.041
3%	UP				7.122	3.442	2.391	1.972	1.854
	DOWN				12.441	4.340	2.794	2.237	2.085
4%	UP				6.646	3.326	2.337	1.934	1.820
	DOWN				[illegible]	4.536	2.875	[illegible]	2.130
5%	UP				[illegible]	3.221	[illegible]	[illegible]	1.787
	DOWN				[illegible]	4.750	2.951	2.342	2.176

43° N

JAN. 21

SHADOW LENGTH = HEIGHT x COEF. HEIGHT = SHADOW LENGTH ÷ COEF.

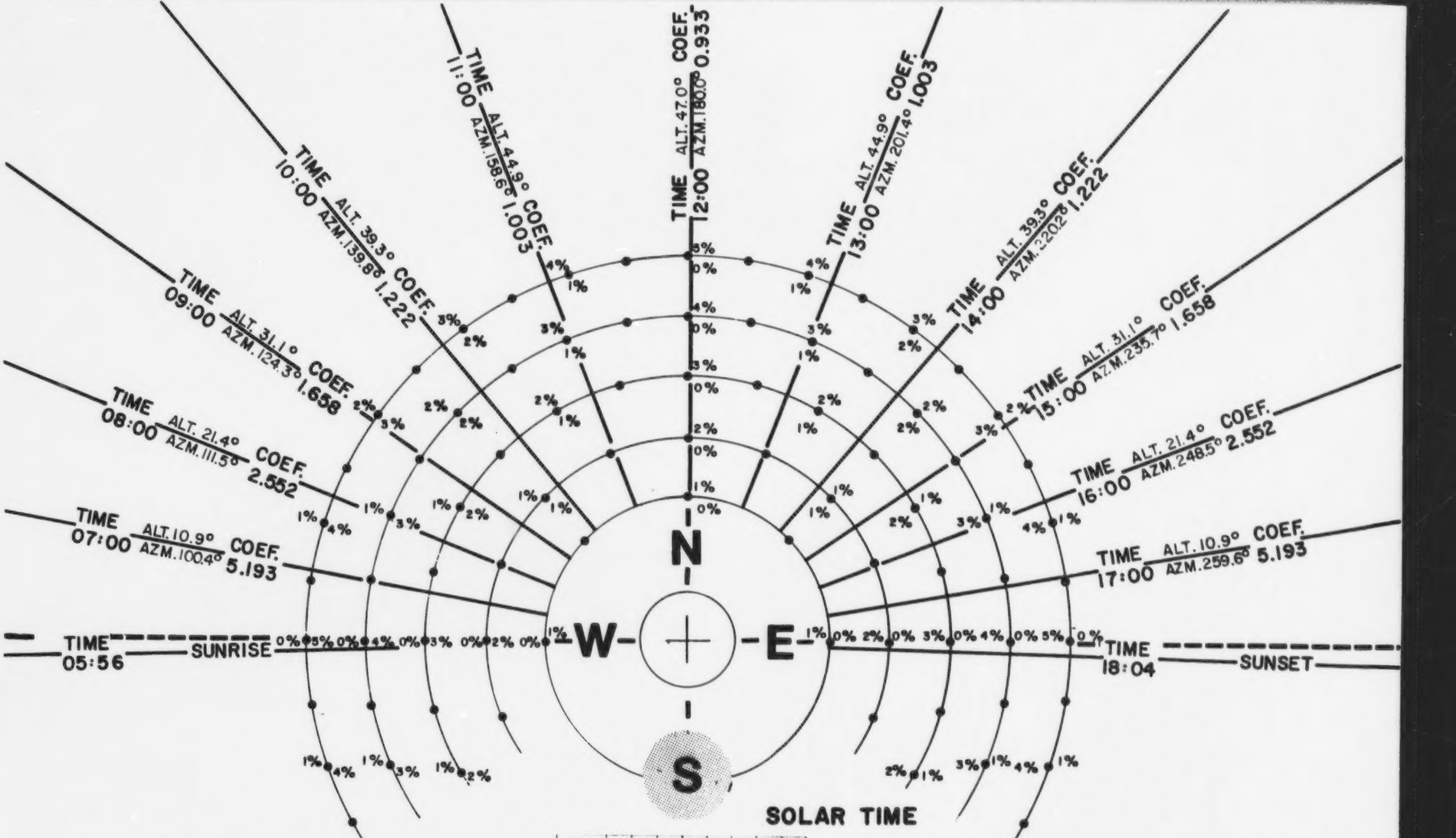

TIME 06:37 SUNRISE
TIME 07:00 ALT. 3.3° AZM. 108.1° COEF. 17.343
TIME 08:00 ALT. 13.4° AZM. 119.0° COEF. 4.197
TIME 09:00 ALT. 22.3° AZM. 131.3° COEF. 2.438
TIME 10:00 ALT. 29.6° AZM. 145.6° COEF. 1.760
TIME 11:00 ALT. 34.5° AZM. 162.0° COEF. 1.455
TIME 12:00 ALT. 36.2° AZM. 180.0° COEF. 1.366
TIME 13:00 ALT. 34.5° AZM. 198.0° COEF. 1.455
TIME 14:00 ALT. 29.6° AZM. 214.4° COEF. 1.760
TIME 15:00 ALT. 22.3° AZM. 228.7° COEF. 2.438
TIME 16:00 ALT. 13.4° AZM. 241.0° COEF. 4.197
TIME 17:00 ALT. 3.3° AZM. 251.9° COEF. 17.343
TIME 17:24 SUNSET
N
S
E
W
5%
4%
3%
2%
1%
0%
SOLAR TIME

SLOPE IN % AND DIRECTION		05:00 19:00 HOURS	06:00 18:00 HOURS	07:00 17:00 HOURS	08:00 16:00 HOURS	09:00 15:00 HOURS	10:00 14:00 HOURS	11:00 13:00 HOURS	12:00 HOURS
1%	UP			13.998	4.028	2.54[illegible]	1.729	1.414	1.348
	DOWN			20.976	4.381	2.495	1.742	1.478	1.385
2%	UP			12.880	3.873	2.320	1.701	1.414	1.330
	DOWN			26.537	4.710	2.56[illegible]	1.824	1.485	1.405
3%	UP			11.405	3.724	2.27[illegible]	1.672	1.398	1.315
	DOWN			36.170	4.801	[illegible]	1.858	1.521	1.421
4%	UP			10.238	3.594	[illegible]	1.644	1.375	1.296
	DOWN			56.888	5.41[illegible]	[illegible]	1.898	[illegible]	1.445
5%	UP			9.260	3.464	2.173	1.616	1.356	1.278
	DOWN			130.171	5.512	2.777	[illegible]	1.568	1.467

43° N

FEB.21

SHADOW LENGTH = HEIGHT x COEF.   HEIGHT = SHADOW LENGTH ÷ COEF.



TIME 05:56 SUNRISE
TIME 07:00 ALT. 10.9° AZM. 100.4° COEF. 5.193
TIME 08:00 ALT. 21.4° AZM. 111.5° COEF. 2.552
TIME 09:00 ALT. 31.1° AZM. 124.3° COEF. 1.658
TIME 10:00 ALT. 39.3° AZM. 139.8° COEF. 1.222
TIME 11:00 ALT. 44.9° AZM. 158.6° COEF. 1.003
TIME 12:00 ALT. 47.0° AZM. 180.0° COEF. 0.933
TIME 13:00 ALT. 44.9° AZM. 201.4° COEF. 1.003
TIME 14:00 ALT. 39.3° AZM. 220.2° COEF. 1.222
TIME 15:00 ALT. 31.1° AZM. 235.7° COEF. 1.658
TIME 16:00 ALT. 21.4° AZM. 248.5° COEF. 2.552
TIME 17:00 ALT. 10.9° AZM. 259.6° COEF. 5.193
TIME 18:04 SUNSET
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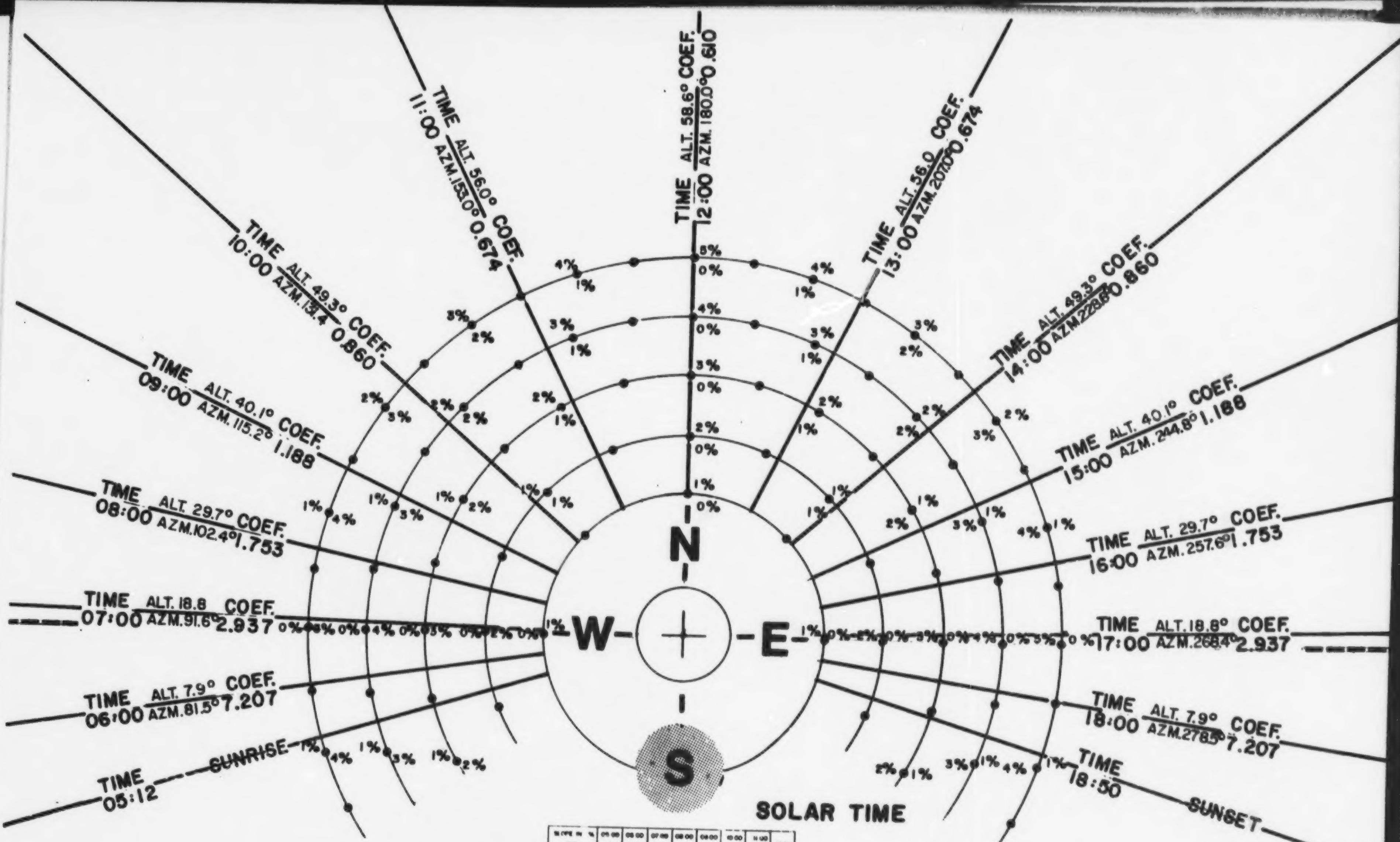
SOLAR TIME
0%
1%
2%
3%
4%
5%

SLOPE IN % AND DIREC TION		05:00 19:00 HOURS	06:00 18:00 HOURS	07:00 17:00 HOURS	08:00 16:00 HOURS	09:00 15:00 HOURS	10:00 14:00 HOURS	11:00 13:00 HOURS	12:00 HOURS
1%	UP			4.936	2.488	1.630	1.207	0.993	0.924
	DOWN			5.477	2.618	1.686	1.277	1.013	0.941
2%	UP			4.706	2.428	1.605	1.193	0.983	0.915
	DOWN			5.794	2.684	1.714	1.252	1.024	0.950
3%	UP			4.493	2.370	1.579	1.179	0.974	0.907
	DOWN			6.153	2.753	1.744	1.268	1.034	0.959
4%	UP			4.296	2.315	1.554	1.164	0.965	0.899
	DOWN			6.555	2.842	1.776	1.285	1.045	1.969
5%	UP			4.123	2.231	1.530	1.152	0.955	0.891
	DOWN			7.013	2.925	1.812	1.301	1.056	0.978

43° N

MARCH 21

SHADOW LENGTH = HEIGHT x COEF. HEIGHT = SHADOW LENGTH ÷ COEF.


TIME 05:12 SUNRISE
TIME 06:00 ALT. 7.9° AZM. 81.5° COEF. 7.207
TIME 07:00 ALT. 18.8 AZM. 91.6° COEF. 2.937
TIME 08:00 ALT. 29.7° AZM. 102.4° COEF. 1.753
TIME 09:00 ALT. 40.1° AZM. 115.2° COEF. 1.188
TIME 10:00 ALT. 49.3° AZM. 131.4 COEF. 0.860
TIME 11:00 ALT. 56.0° AZM. 153.0° COEF. 0.674
TIME 12:00 ALT. 58.6° AZM. 180.0° COEF. 0.610
TIME 13:00 ALT. 56.0 AZM. 207.0° COEF. 0.674
TIME 14:00 ALT. 49.3° AZM. 228.6° COEF. 0.860
TIME 15:00 ALT. 40.1° AZM. 244.8° COEF. 1.188
TIME 16:00 ALT. 29.7° AZM. 257.6° COEF. 1.753
TIME 17:00 ALT. 18.8° AZM. 268.4° COEF. 2.937
TIME 18:00 ALT. 7.9° AZM. 278.5° COEF. 7.207
TIME 18:50 SUNSET
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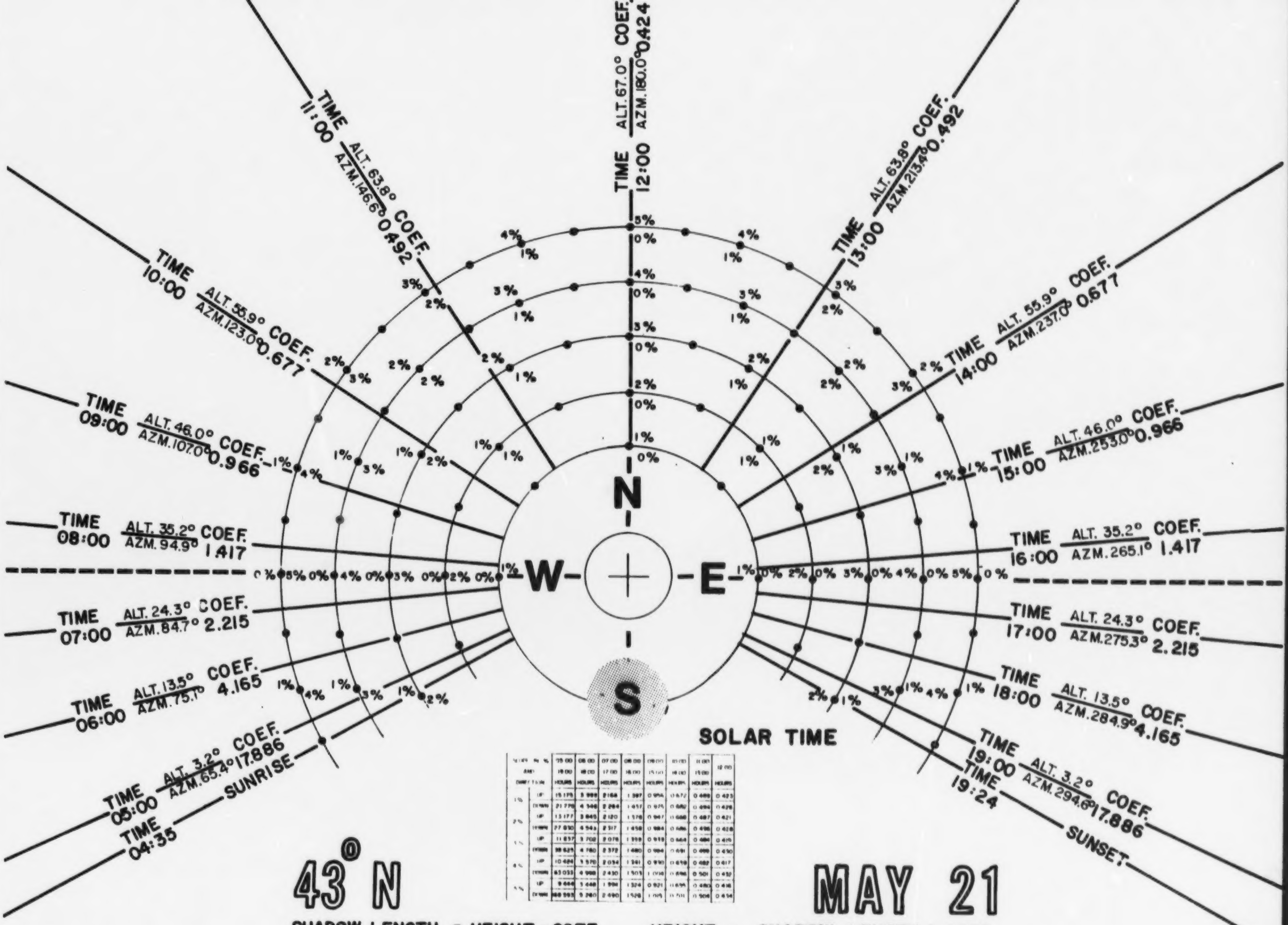
3%
4%
5%
0%
SOLAR TIME

SLOPE IN % AND DIRECTION		05:00 19:00 HOURS	06:00 18:00 HOURS	07:00 17:00 HOURS	08:00 16:00 HOURS	09:00 15:00 HOURS	10:00 14:00 HOURS	11:00 13:00 HOURS	12:00 HOURS
1%	UP		6.722	2.853	1.723	1.173	0.846	0.669	0.607
	DOWN		7.785	3.026	1.784	1.201	0.863	0.679	0.614
2%	UP		6.299	2.774	1.694	1.167	0.841	0.665	0.605
	DOWN		8.419	3.120	1.816	1.216	0.870	0.683	0.618
3%	UP		5.923	2.699	1.665	1.147	0.833	0.661	0.599
	DOWN		9.284	3.222	1.850	1.231	0.878	0.688	0.621
4%	UP		5.596	2.628	1.638	1.134	0.827	0.657	0.596
	DOWN		10.089	3.329	1.885	1.247	0.887	0.693	0.625
5%	UP		5.298	2.561	1.612	1.121	0.820	0.652	0.592
	DOWN		11.263	3.445	1.922	1.262	0.894	0.698	0.630

43° N

APRIL 21

SHADOW LENGTH = HEIGHT x COEF.   HEIGHT = SHADOW LENGTH ÷ COEF.


TIME 04:35 SUNRISE
TIME 05:00 ALT. 3.2° AZM. 65.4° COEF. 17.886
TIME 06:00 ALT. 13.5° AZM. 75.1° COEF. 4.165
TIME 07:00 ALT. 24.3° AZM. 84.7° COEF. 2.215
TIME 08:00 ALT. 35.2° AZM. 94.9° COEF. 1.417
TIME 09:00 ALT. 46.0° AZM. 107.0° COEF. 0.966
TIME 10:00 ALT. 55.9° AZM. 123.0° COEF. 0.677
TIME 11:00 ALT. 63.8° AZM. 146.6° COEF. 0.492
TIME 12:00 ALT. 67.0° AZM. 180.0° COEF. 0.424
TIME 13:00 ALT. 63.8° AZM. 213.4° COEF. 0.492
TIME 14:00 ALT. 55.9° AZM. 237.0° COEF. 0.677
TIME 15:00 ALT. 46.0° AZM. 253.0° COEF. 0.966
TIME 16:00 ALT. 35.2° AZM. 265.1° COEF. 1.417
TIME 17:00 ALT. 24.3° AZM. 275.3° COEF. 2.215
TIME 18:00 ALT. 13.5° AZM. 284.9° COEF. 4.165
TIME 19:00 ALT. 3.2° AZM. 294.6° COEF. 17.886
TIME 19:24 SUNSET
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1% 0%
2% 0%
3% 0%
4% 0%
5% 0%

SOLAR TIME

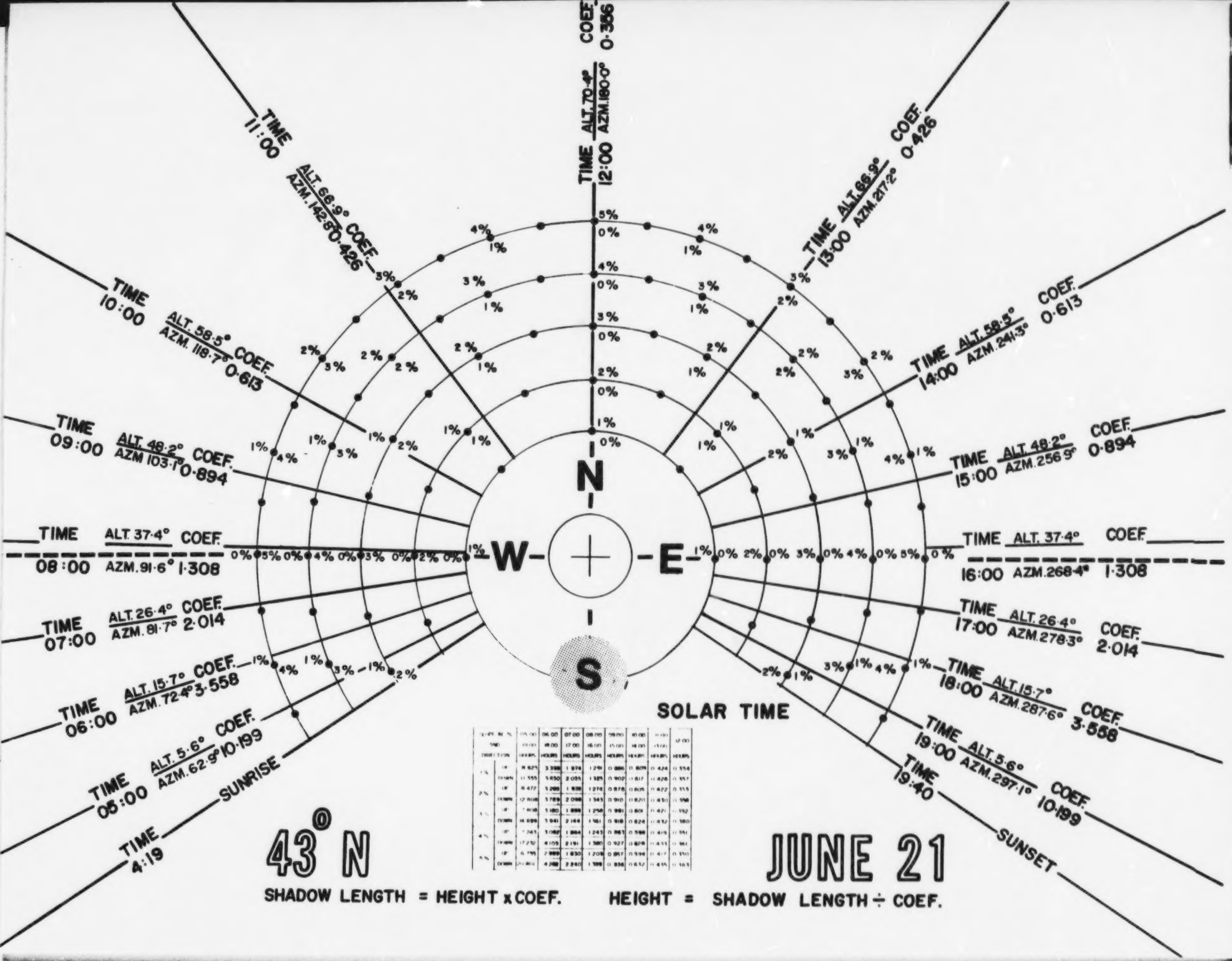
SLOPE IN % AND DIRECTION		05:00 19:00 HOURS	06:00 18:00 HOURS	07:00 17:00 HOURS	08:00 16:00 HOURS	09:00 15:00 HOURS	10:00 14:00 HOURS	11:00 13:00 HOURS	12:00 HOURS
1%	UP	15.175	3.999	2.164	1.387	0.954	0.672	0.489	0.423
	DOWN	[illegible]	4.346	2.284	[illegible]	0.975	0.682	0.494	0.426
2%	UP	13.177	3.845	2.120	1.376	0.947	0.668	0.487	0.421
	DOWN	27.830	[illegible]	2.317	1.458	0.984	0.686	0.496	0.428
3%	UP	11.837	3.702	2.076	1.359	[illegible]	0.664	0.484	0.419
	DOWN	38.625	4.760	2.372	1.480	0.994	0.691	0.499	0.430
4%	UP	10.484	3.570	2.034	1.341	0.930	0.659	0.482	0.417
	DOWN	63.033	[illegible]	2.430	1.503	[illegible]	0.696	0.501	0.432
5%	UP	9.444	3.448	1.994	1.324	0.921	0.655	0.480	0.416
	DOWN	168.393	5.260	2.490	1.526	[illegible]	0.701	0.504	0.434

43° N

MAY 21

SHADOW LENGTH = HEIGHT x COEF.

HEIGHT = SHADOW LENGTH ÷ COEF.


TIME 12:00 ALT. 70·4° AZM.180·0° COEF. 0·356
TIME 11:00 ALT. 66·9° AZM. 142·8° COEF. 0·426
TIME 13:00 ALT. 66·9° AZM. 217·2° COEF. 0·426
TIME 10:00 ALT. 58·5° AZM. 118·7° COEF. 0·613
TIME 14:00 ALT. 58·5° AZM. 241·3° COEF. 0·613
TIME 09:00 ALT. 48·2° AZM 103·1° COEF. 0·894
TIME 15:00 ALT. 48·2° AZM. 256·9° COEF. 0·894
TIME 08:00 ALT. 37·4° AZM. 91·6° COEF. 1·308
TIME 16:00 ALT. 37·4° AZM. 268·4° COEF. 1·308
TIME 07:00 ALT. 26·4° AZM. 81·7° COEF. 2·014
TIME 17:00 ALT. 26·4° AZM. 278·3° COEF. 2·014
TIME 06:00 ALT. 15·7° AZM. 72·4° COEF. 3·558
TIME 18:00 ALT. 15·7° AZM. 287·6° COEF. 3·558
TIME 05:00 ALT. 5·6° AZM. 62·9° COEF. 10·199
TIME 19:00 ALT. 5·6° AZM. 297·1° COEF. 10·199
TIME 4:19 SUNRISE
TIME 19:40 SUNSET
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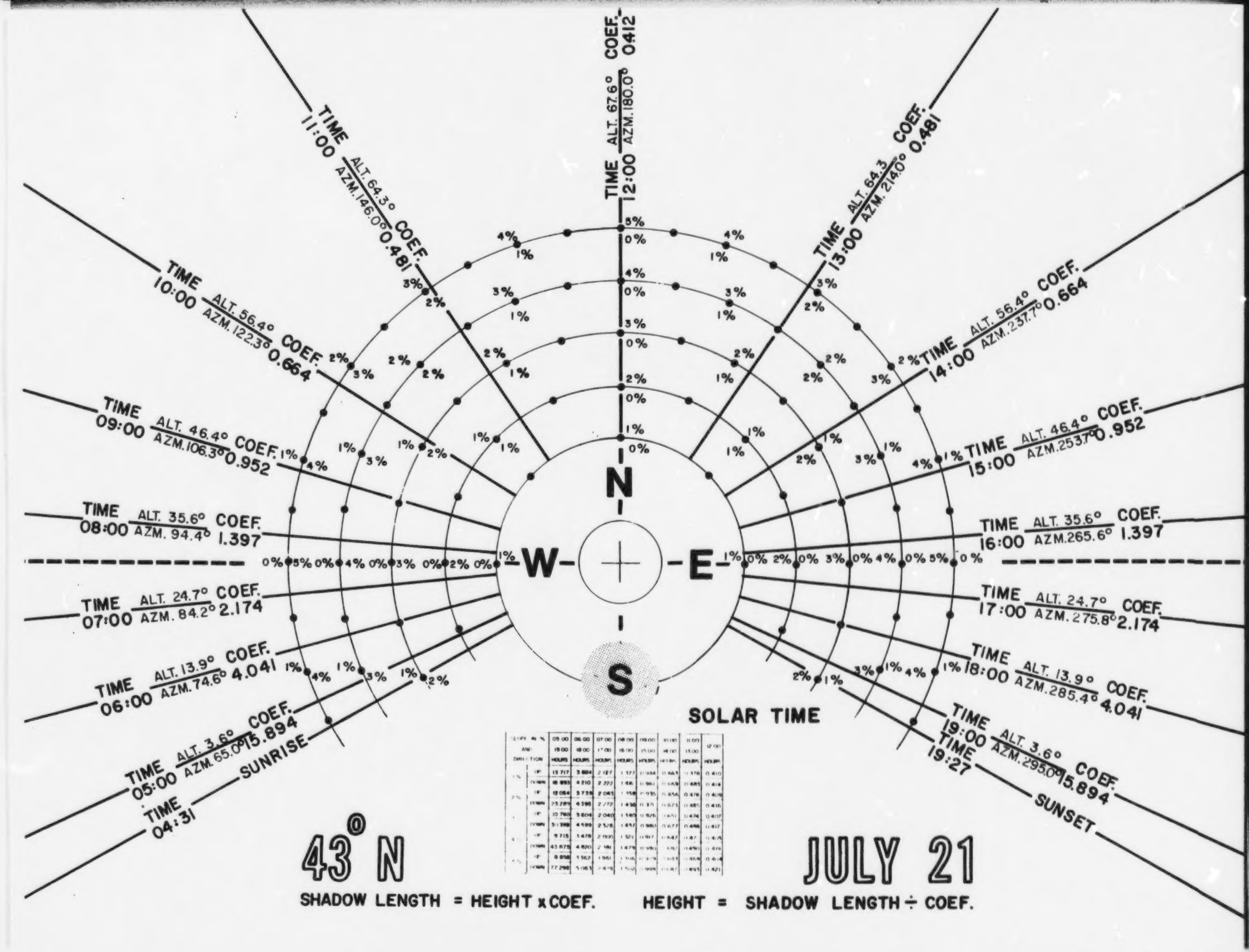
1%
2%
3%
4%
5%
SOLAR TIME

SLOPE IN % AND DIRECTION		05:00 19:00 HOURS	06:00 18:00 HOURS	07:00 17:00 HOURS	08:00 16:00 HOURS	09:00 15:00 HOURS	10:00 14:00 HOURS	11:00 13:00 HOURS	12:00 HOURS
1%	UP	8.625	3.388	1.974	1.291	0.886	0.609	0.424	0.354
	DOWN	11.555	3.850	2.055	1.325	0.902	0.617	0.428	0.357
2%	UP	8.472	3.288	1.938	1.274	0.878	0.605	0.422	0.355
	DOWN	12.808	3.789	2.098	1.343	0.910	0.620	0.430	0.358
3%	UP	[illegible]	3.180	1.899	1.258	0.861	0.601	0.421	0.352
	DOWN	14.699	3.941	2.144	1.361	0.918	0.624	0.432	0.360
4%	UP	7.243	3.082	1.864	1.243	0.861	0.598	0.419	0.351
	DOWN	17.232	4.105	2.191	1.380	0.927	0.628	0.433	0.361
5%	UP	[illegible]	2.989	1.830	1.209	0.857	0.594	0.417	0.350
	DOWN	[illegible]	4.288	2.240	1.399	0.936	0.632	0.435	0.363

43° N

JUNE 21

SHADOW LENGTH = HEIGHT x COEF. HEIGHT = SHADOW LENGTH ÷ COEF.


TIME 12:00 ALT. 67.6° AZM. 180.0° COEF. 0412
TIME 11:00 ALT. 64.3° AZM. 146.0° COEF. 0.481
TIME 13:00 ALT. 64.3 AZM. 214.0° COEF. 0.481
TIME 10:00 ALT. 56.4° AZM. 122.3° COEF. 0.664
TIME 14:00 ALT. 56.4° AZM. 237.7° COEF. 0.664
TIME 09:00 ALT. 46.4° AZM. 106.3° COEF. 0.952
TIME 15:00 ALT. 46.4° AZM. 253.7° COEF. 0.952
TIME 08:00 ALT. 35.6° AZM. 94.4° COEF. 1.397
TIME 16:00 ALT. 35.6° AZM. 265.6° COEF. 1.397
TIME 07:00 ALT. 24.7° AZM. 84.2° COEF. 2.174
TIME 17:00 ALT. 24.7° AZM. 275.8° COEF. 2.174
TIME 06:00 ALT. 13.9° AZM. 74.6° COEF. 4.041
TIME 18:00 ALT. 13.9° AZM. 285.4° COEF. 4.041
TIME 05:00 ALT. 3.6° AZM. 65.0° COEF. 15.894
TIME 19:00 ALT. 3.6° AZM. 295.0° COEF. 15.894
TIME 04:31 SUNRISE
TIME 19:27 SUNSET
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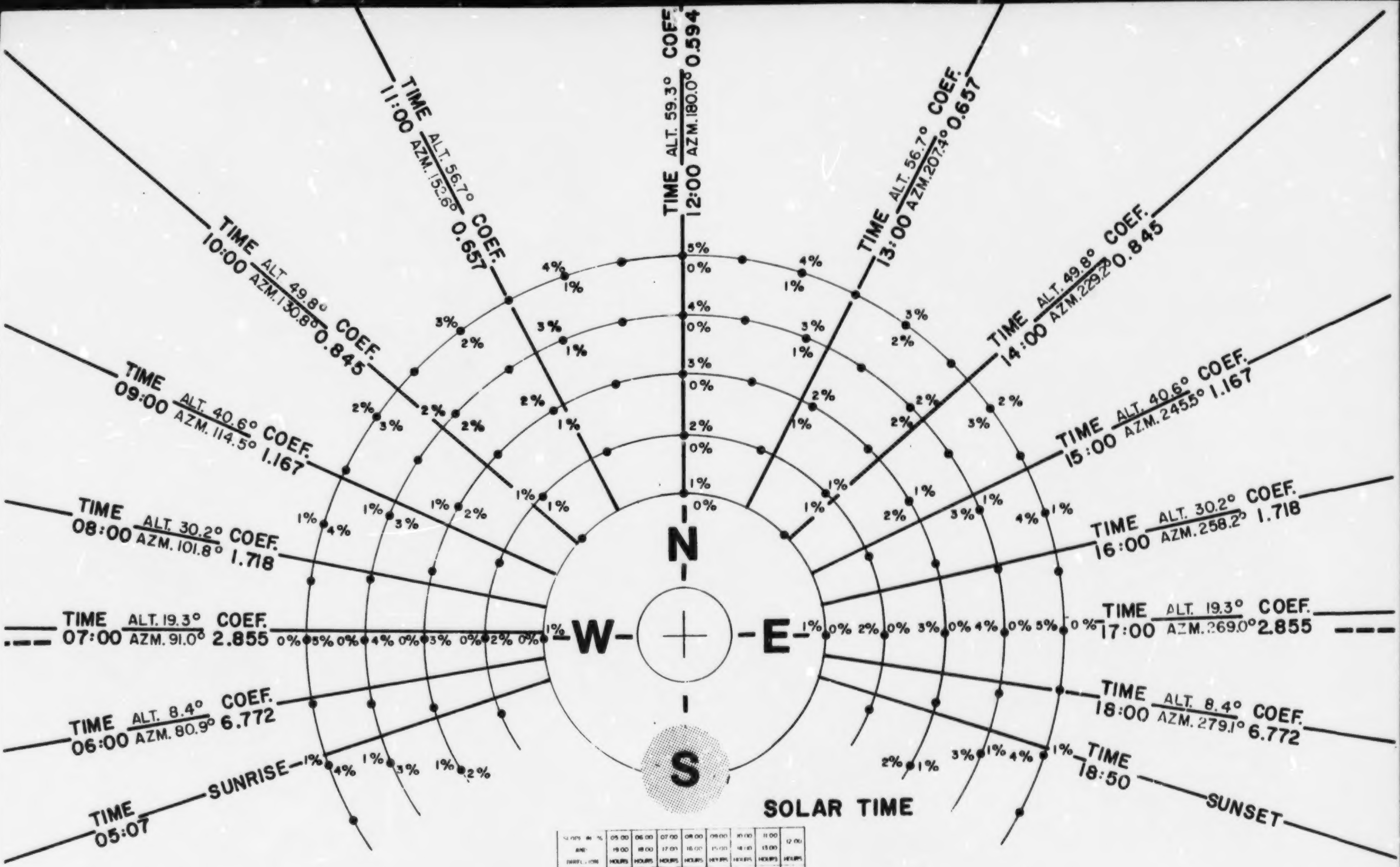
SOLAR TIME
0%
1%
2%
3%
4%
5%

43° N

JULY 21

SHADOW LENGTH = HEIGHT x COEF.

HEIGHT = SHADOW LENGTH ÷ COEF.


TIME 05:07 SUNRISE
TIME 06:00 ALT. 8.4° AZM. 80.9° COEF. 6.772
TIME 07:00 ALT. 19.3° AZM. 91.0° COEF. 2.855
TIME 08:00 ALT. 30.2° AZM. 101.8° COEF. 1.718
TIME 09:00 ALT. 40.6° AZM. 114.5° COEF. 1.167
TIME 10:00 ALT. 49.8° AZM. 130.8° COEF. 0.845
TIME 11:00 ALT. 56.7° AZM. 152.6° COEF. 0.657
TIME 12:00 ALT. 59.3° AZM. 180.0° COEF. 0.594
TIME 13:00 ALT. 56.7° AZM. 207.4° COEF. 0.657
TIME 14:00 ALT. 49.8° AZM. 229.2° COEF. 0.845
TIME 15:00 ALT. 40.6° AZM. 245.5° COEF. 1.167
TIME 16:00 ALT. 30.2° AZM. 258.2° COEF. 1.718
TIME 17:00 ALT. 19.3° AZM. 269.0° COEF. 2.855
TIME 18:00 ALT. 8.4° AZM. 279.1° COEF. 6.772
TIME 18:50 SUNSET
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0% 5% 0% 4% 0% 3% 0% 2% 0% 1%
1% 0% 2% 0% 3% 0% 4% 0% 5% 0%
5% 0% 4% 0% 3% 0% 2% 0% 1% 0%
1% 4% 1% 3% 1% 2%
2% 1% 3% 1% 4% 1%

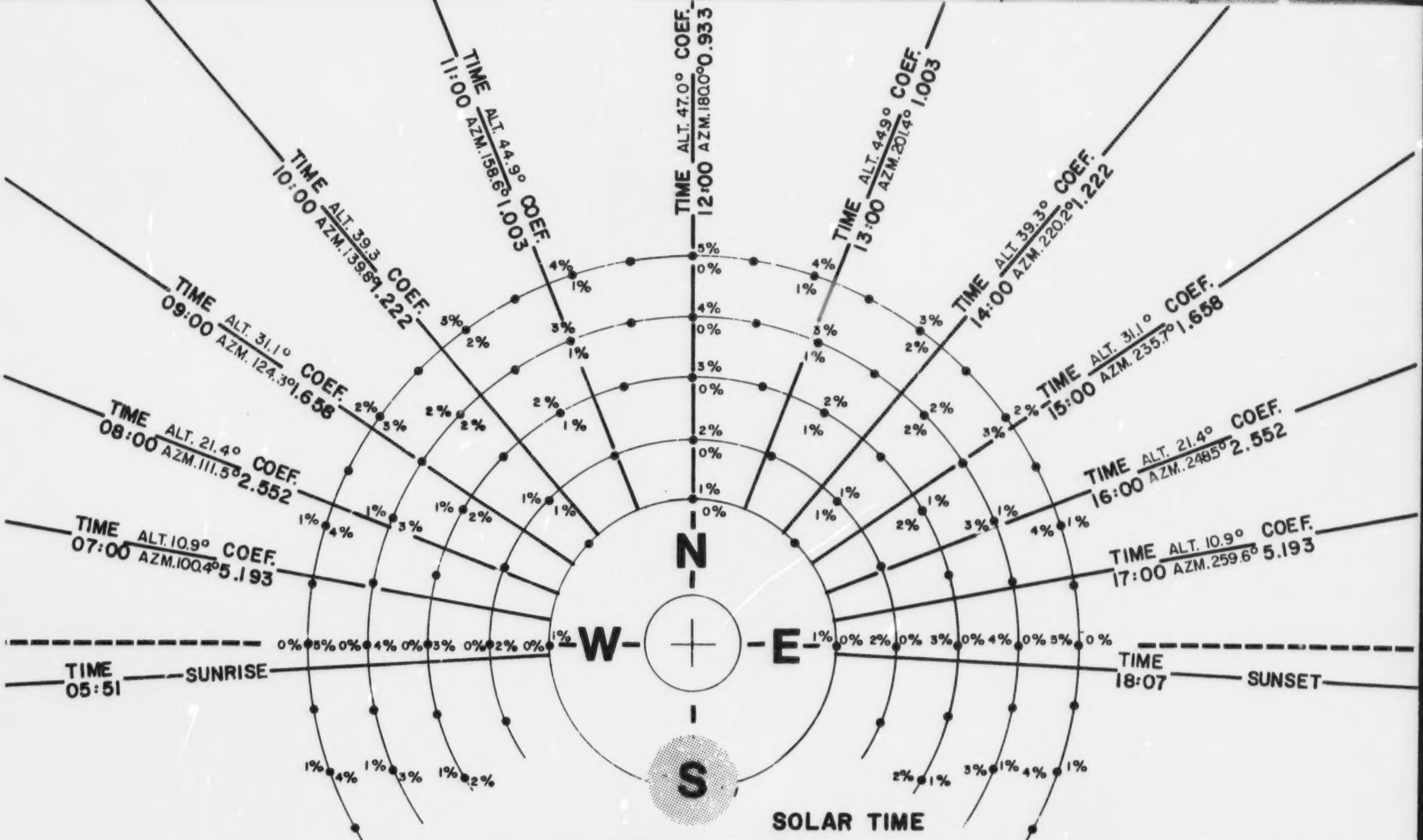
SOLAR TIME

SLOPE IN % AND DIRECTION		05:00 19:00 HOURS	06:00 18:00 HOURS	07:00 17:00 HOURS	08:00 16:00 HOURS	09:00 15:00 HOURS	10:00 14:00 HOURS	11:00 13:00 HOURS	12:00 HOURS
1%	UP		6.342	2.778	1.689	1.153	0.938	0.857	0.590
	DOWN		7.263	2.939	1.748	1.180	0.952	0.861	0.597
2%	UP		5.965	2.701	1.661	1.140	0.831	0.848	0.587
	DOWN		7.831	3.028	1.779	1.194	0.959	0.865	0.601
3%	UP		5.626	2.630	1.635	1.127	0.824	0.844	0.583
	DOWN		8.499	3.123	1.811	1.208	0.967	0.870	0.605
4%	UP		5.326	2.563	1.607	1.115	0.817	0.840	0.580
	DOWN		9.269	3.224	1.845	1.224	0.975	0.874	0.608
5%	UP		5.059	2.494	1.582	1.103	0.811	0.836	0.606
	DOWN		10.247	3.331	1.879	1.238	0.982	0.879	0.612

43° N

AUG. 21

SHADOW LENGTH = HEIGHT x COEF. HEIGHT = SHADOW LENGTH ÷ COEF.


TIME 05:51 SUNRISE
TIME 07:00 ALT. 10.9° AZM. 100.4° COEF. 5.193
TIME 08:00 ALT. 21.4° AZM. 111.5° COEF. 2.552
TIME 09:00 ALT. 31.1° AZM. 124.3° COEF. 1.658
TIME 10:00 ALT. 39.3 AZM. 139.8° COEF. 1.222
TIME 11:00 ALT. 44.9° AZM. 158.6° COEF. 1.003
TIME 12:00 ALT. 47.0° AZM. 180.0° COEF. 0.933
TIME 13:00 ALT. 44.9° AZM. 201.4° COEF. 1.003
TIME 14:00 ALT. 39.3° AZM. 220.2° COEF. 1.222
TIME 15:00 ALT. 31.1° AZM. 235.7° COEF. 1.658
TIME 16:00 ALT. 21.4° AZM. 248.5° COEF. 2.552
TIME 17:00 ALT. 10.9° AZM. 259.6° COEF. 5.193
TIME 18:07 SUNSET
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SOLAR TIME
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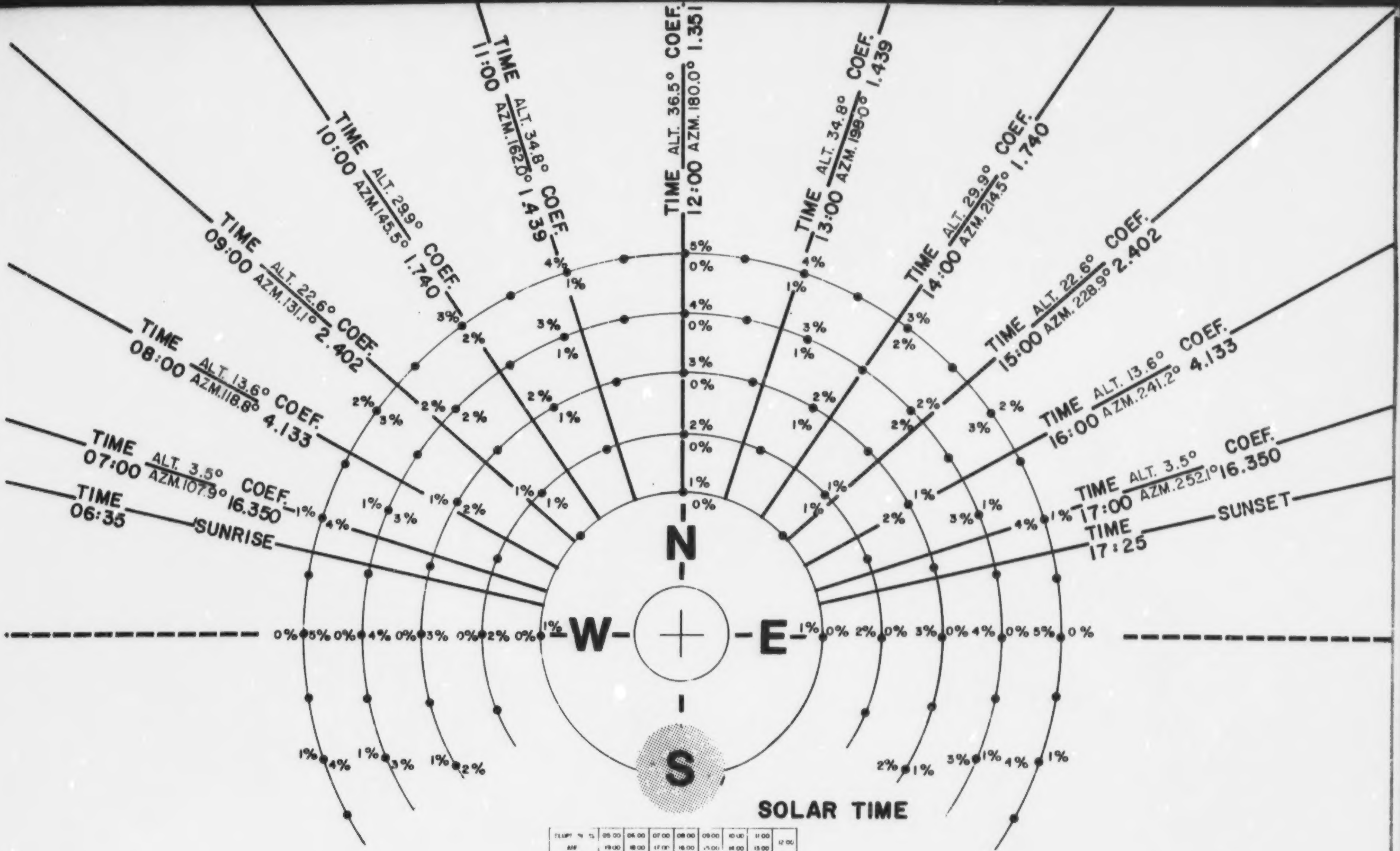
5%

SLOPE IN % AND DIRECTION		05:00 19:00 HOURS	06:00 18:00 HOURS	07:00 17:00 HOURS	08:00 16:00 HOURS	09:00 15:00 HOURS	10:00 14:00 HOURS	11:00 13:00 HOURS	12:00 HOURS
1%	UP			6.936	2.480	1.631	1.207	0.985	0.924
	DOWN			5.477	2.618	1.689	1.238	1.013	0.941
2%	UP			4.704	2.427	1.606	1.193	0.983	0.915
	DOWN			5.784	2.688	1.714	1.252	1.024	0.950
3%	UP			4.493	2.370	1.579	1.179	0.974	0.907
	DOWN			6.152	2.763	1.745	1.266	1.034	0.959
4%	UP			4.299	2.315	1.555	1.165	0.964	0.898
	DOWN			6.555	2.842	1.776	1.285	1.045	0.969
5%	UP			4.123	2.263	1.531	1.152	0.955	0.891
	DOWN			7.013	[illegible]	[illegible]	1.301	1.565	0.978

43° N

SEPT. 21

SHADOW LENGTH = HEIGHT x COEF. HEIGHT = SHADOW LENGTH ÷ COEF.


TIME 06:35 SUNRISE
TIME 07:00 ALT. 3.5° AZM.107.9° COEF. 16.350
TIME 08:00 ALT. 13.6° AZM.118.8° COEF. 4.133
TIME 09:00 ALT. 22.6° AZM.131.1° COEF. 2.402
TIME 10:00 ALT. 29.9° AZM.145.5° COEF. 1.740
TIME 11:00 ALT. 34.8° AZM.162.0° COEF. 1.439
TIME 12:00 ALT. 36.5° AZM. 180.0° COEF. 1.351
TIME 13:00 ALT. 34.8° AZM. 198.0° COEF. 1.439
TIME 14:00 ALT. 29.9° AZM. 214.5° COEF. 1.740
TIME 15:00 ALT. 22.6° AZM. 228.9° COEF. 2.402
TIME 16:00 ALT. 13.6° AZM. 241.2° COEF. 4.133
TIME 17:00 ALT. 3.5° AZM. 252.1° COEF. 16.350
TIME 17:25 SUNSET
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0% 5% 0% 4% 0% 3% 0% 2% 0% 1%
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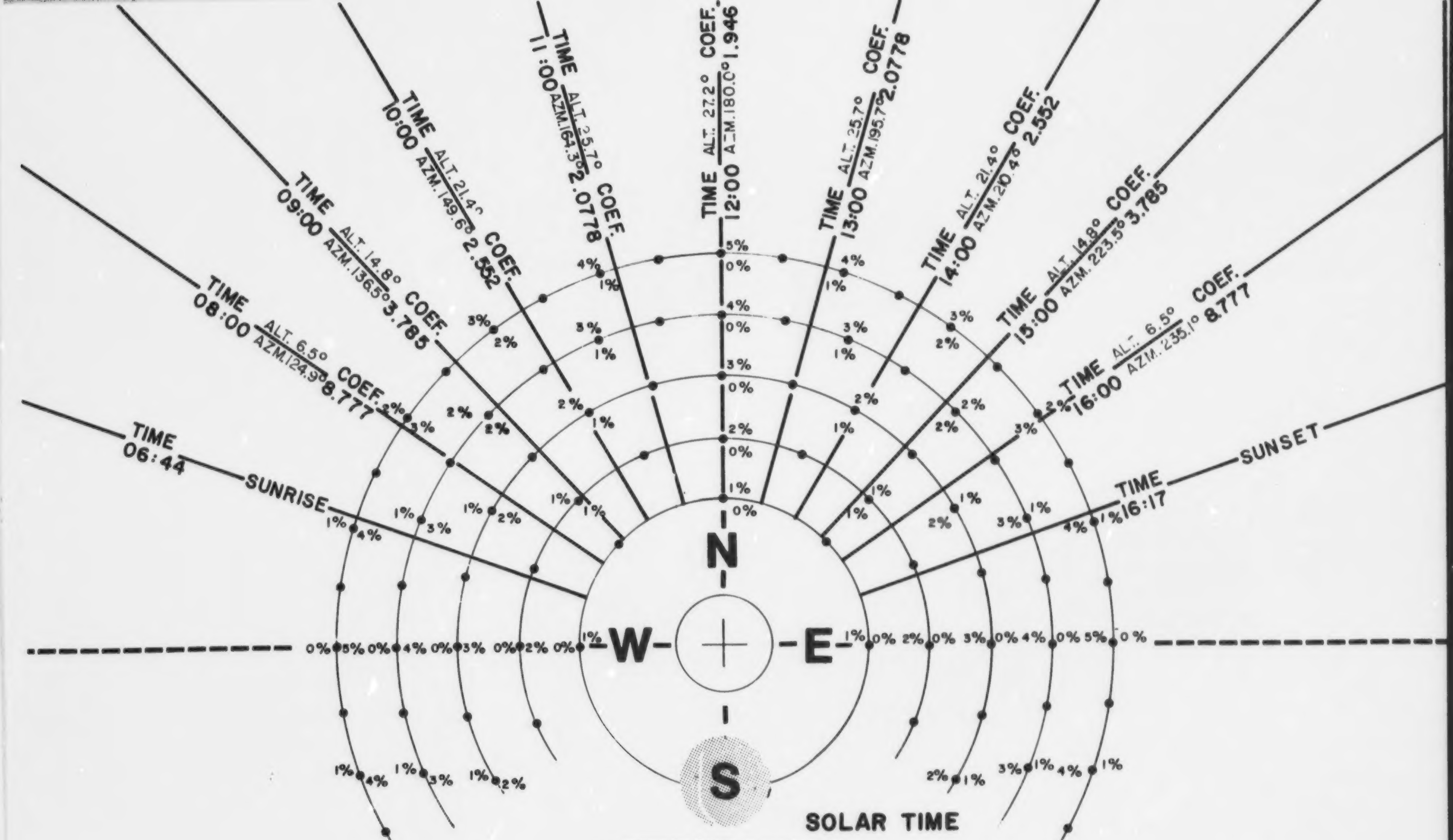
SOLAR TIME

SLOPE %		05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00
AM		19:00	18:00	17:00	16:00	15:00	14:00	13:00	
[illegible]		HOURS	HOURS	HOURS	HOURS	HOURS	HOURS	HOURS	HOURS
1%	UP			14.049	3.989	2.345	1.709	1.418	1.351
	DOWN			19.540	4.311	2.461	1.769	1.459	1.370
2%	UP			12.324	3.818	2.292	1.681	1.398	1.315
	DOWN			24.280	4.505	2.523	1.802	1.481	1.389
3%	UP			10.279	3.677	2.241	1.646	1.379	1.298
	DOWN			32.105	4.719	2.589	1.835	1.503	1.409
4%	UP			9.003	3.573	2.192	1.614	1.360	1.282
	DOWN			47.294	4.957	2.658	1.869	1.526	1.427
5%	UP			8.098	3.426	2.145	1.600	1.342	1.266
	DOWN			99.403	5.209	2.730	1.904	1.549	1.449

43° N

OCT. 21

SHADOW LENGTH = HEIGHT x COEF.   HEIGHT = SHADOW LENGTH ÷ COEF.


TIME 06:44 SUNRISE
TIME 08:00 ALT. 6.5° AZM.124.9° COEF. 8.777
TIME 09:00 ALT. 14.8° AZM.136.5° COEF. 3.785
TIME 10:00 ALT. 21.4° AZM.149.6° COEF. 2.552
TIME 11:00 ALT. 25.7° AZM.164.3° COEF. 2.0778
TIME 12:00 ALT. 27.2° AZM.180.0° COEF. 1.946
TIME 13:00 ALT. 25.7° AZM.195.7° COEF. 2.0778
TIME 14:00 ALT. 21.4° AZM.210.4° COEF. 2.552
TIME 15:00 ALT. 14.8° AZM. 223.5° COEF. 3.785
TIME 16:00 ALT. 6.5° AZM. 235.1° COEF. 8.777
TIME 16:17 SUNSET
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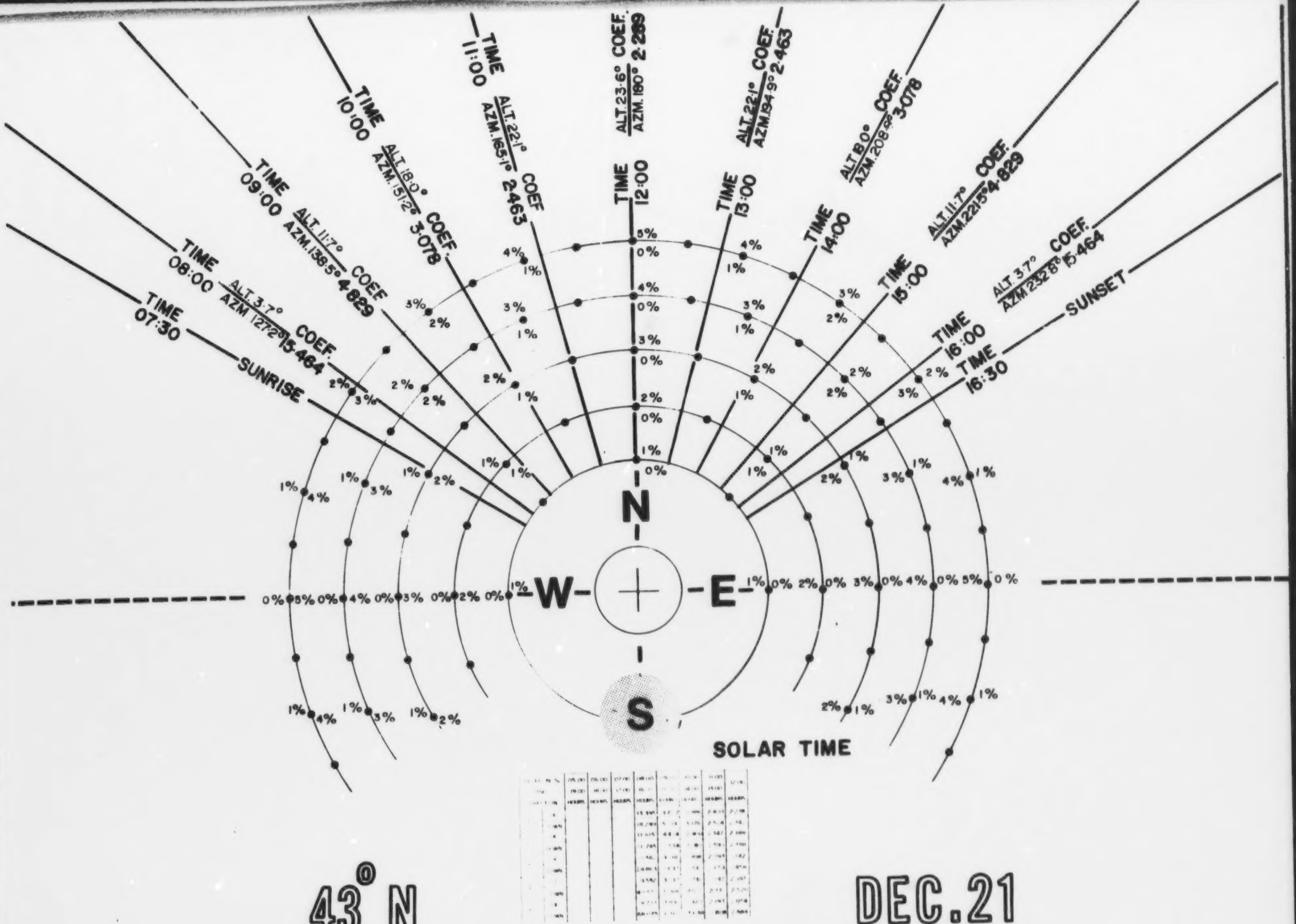
SOLAR TIME

SLOPE IN % AND DIRECTION		05:00 19:00 HOURS	06:00 18:00 HOURS	07:00 17:00 HOURS	08:00 16:00 HOURS	09:00 15:00 HOURS	10:00 14:00 HOURS	11:00 13:00 HOURS	12:00 HOURS
1%	UP				8.09[illegible]	3.647	2.488	2.035	1.909
	DOWN				9.620	3.934	2.619	2.121	1.984
2%	UP				7.467	3.519	2.428	1.995	1.873
	DOWN				10.643	4.1[illegible]	[illegible]688	2.167	2.024
3%	UP				6.946	3.3[illegible]	[illegible]370	1.955	1.838
	DOWN				11.9[illegible]	4.[illegible]	[illegible]763	2.176	2.066
4%	UP				6.495	3.287	2.315	1.918	1.805
	DOWN				13.529	4.594	2.817	2.286	2.110
5%	UP				6.101	3.165	2.262	1.862	1.773
	DOWN				15.695	5.068	2.925	2.308	2.156

43° N

NOV. 21

SHADOW LENGTH = HEIGHT x COEF. HEIGHT = SHADOW LENGTH ÷ COEF.


TIME 07:30 SUNRISE
TIME 08:00 ALT. 3·7° AZM 127·2° COEF. 15·464
TIME 09:00 ALT. 11·7° AZM.138·5° COEF 4·829
TIME 10:00 ALT. 18·0° AZM.151·2° COEF. 3·078
TIME 11:00 ALT. 22·1° AZM.165·1° COEF 2·463
TIME 12:00 ALT. 23·6° AZM. 180° COEF. 2·289
TIME 13:00 ALT. 22·1° AZM.194·9° COEF. 2·463
TIME 14:00 ALT. 18·0° AZM. 208·8° COEF. 3·078
TIME 15:00 ALT. 11·7° AZM.221·5° COEF. 4·829
TIME 16:00 ALT. 3·7° AZM 232·8° COEF. 15·464
TIME 16:30 SUNSET
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SOLAR TIME

43° N

DEC.21

SHADOW LENGTH = HEIGHT x COEF. HEIGHT = SHADOW LENGTH ÷ COEF.

AIR TEMPERATURE: DEGREES CELSIUS (°C)

		1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	MEAN
JANUARY	Mean Maximum	- 0.8	- 4.4	- 3.8	- 0.7	- 0.3	- 1.1	0.8	- 4.3	- 8.2	- 4.5	- 2.7
	Mean Minimum	- 8.2	-12.9	-11.7	- 9.6	- 7.4	- 8.6	- 6.3	-13.8	-15.3	-11.5	-10.5
	Mean	- 4.5	- 8.7	- 7.7	- 5.1	- 3.8	- 4.8	- 2.7	- 9.1	-11.8	- 8.0	- 6.6
FEBRUARY	Mean Maximum	- 0.1	- 0.6	- 1.5	- 2.4	- 2.0	- 2.6	- 1.0	2.0	- 2.5	- 5.6	- 1.6
	Mean Minimum	- 6.4	- 8.8	- 7.9	-11.4	-11.6	-10.8	- 6.2	- 6.8	- 9.1	-15.6	- 9.4
	Mean	- 3.2	- 4.7	- 4.7	- 6.9	- 7.2	- 6.7	- 3.6	- 2.0	- 5.8	-10.3	- 5.5
MARCH	Mean Maximum	3.1	2.6	0.8	0.4	7.2	3.3	1.1	5.8	7.2	0.3	3.2
	Mean Minimum	- 4.3	- 4.5	- 6.0	- 6.9	- 0.3	- 4.4	- 6.9	- 3.2	- 2.4	- 8.2	- 4.6
	Mean	- 0.6	- 0.9	- 2.6	- 3.2	3.4	- 0.6	- 2.4	1.3	2.4	- 4.0	- 0.7
APRIL	Mean Maximum	12.2	12.4	10.7	8.7	10.7	12.7	7.9	13.5	13.3	8.7	11.2
	Mean Minimum	2.4	2.3	- 0.1	- 1.2	2.1	2.1	- 1.1	2.3	2.1	0.0	1.1
	Mean	7.3	7.4	5.3	3.8	6.4	7.4	3.4	7.9	7.7	4.0	6.2
MAY	Mean Maximum	17.7	18.3	18.6	19.8	16.7	15.8	21.8	16.5	21.8	18.4	18.4
	Mean Minimum	7.2	7.4	6.3	8.7	6.4	5.3	10.4	5.7	8.7	7.4	7.4
	Mean	12.4	12.9	12.5	14.2	11.1	10.6	16.1	11.1	15.2	12.9	12.9
JUNE	Mean Maximum	21.9	24.2	24.9	21.0	24.6	22.7	23.6	25.3	23.0	24.0	23.5
	Mean Minimum	12.6	13.7	14.3	11.5	13.9	12.6	14.3	14.1	11.4	11.3	13.0
	Mean	17.3	18.9	19.6	16.3	19.2	17.7	18.9	19.7	17.2	17.7	18.2
JULY	Mean Maximum	26.2	26.7	25.9	25.9	25.9	26.4	27.0	24.7	26.6	26.3	26.3
	Mean Minimum	16.8	17.0	14.2	15.5	15.5	14.7	15.2	14.3	15.7	13.8	15.3
	Mean	21.6	21.9	20.1	20.8	21.2	20.6	21.1	19.5	21.2	20.1	20.8
AUGUST	Mean Maximum	29.3	25.7	26.1	24.3	27.7	26.1	24.6	24.2	24.2	26.0	25.9
	Mean Minimum	17.6	16.3	13.3	14.3	16.6	14.9	14.0	13.2	13.6	14.5	14.9
	Mean	23.4	21.5	19.7	19.3	22.2	20.5	19.7	18.7	18.9	20.3	20.4
SEPTEMBER	Mean Maximum	22.3	21.9	22.5	21.4	22.4	19.4	18.6	18.6	19.9	21.0	20.7
	Mean Minimum	12.4	12.7	12.9	11.2	10.2	8.8	8.6	8.8	12.3	10.1	10.8
	Mean	17.3	17.3	17.7	16.3	16.3	14.1	13.3	13.7	16.1	15.6	15.8
OCTOBER	Mean Maximum	14.4	15.3	17.9	11.4	15.9	13.1	15.2	10.7	13.3	13.1	14.0
	Mean Minimum	6.0	8.2	8.6	2.2	6.7	2.7	5.6	2.3	4.3	3.8	5.0
	Mean	10.2	11.8	13.2	6.8	11.3	7.9	10.4	6.5	8.8	8.5	9.5
NOVEMBER	Mean Maximum	7.7	8.7	6.9	4.1	7.0	7.1	11.4	3.5	7.3	7.6	7.1
	Mean Minimum	1.3	2.6	- 0.8	- 1.3	0.6	0.3	2.8	- 4.1	1.3	- 1.3	0.1
	Mean	4.5	5.7	3.1	1.4	3.8	3.7	7.1	- 0.3	4.3	3.2	3.6
DECEMBER	Mean Maximum	- 0.7	0.6	3.8	1.3	- 0.6	1.2	0.2	- 2.9	- 0.8	1.2	0.4
	Mean Minimum	- 6.9	- 5.9	- 4.4	- 5.3	- 6.9	- 4.1	- 7.6	-11.4	- 6.8	- 5.9	- 6.8
	Mean	- 3.8	- 2.7	- 0.3	- 2.0	- 3.7	- 1.4	- 3.7	- 7.2	- 3.7	- 2.4	- 3.1
YEARLY	Mean Maximum											12.3
	Mean Minimum											3.2
	Mean											7.5

SOURCE: Environment Canada

HOURS OF SUNSHINE

		1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	MEAN
JANUARY	Possible											290.6
	Actual	96.3	83.0	92.7	101.9	129.2	86.4	85.5	103.6	92.5	79.4	95.2
FEBRUARY	Possible											292.9
	Actual	132.0	129.4	68.1	97.8	104.1	142.7	72.3	113.3	110.3	Missing	107.8
MARCH	Possible											368.1
	Actual	162.2	141.6	136.0	119.6	96.9	125.7	144.5	121.5	161.1	Missing	136.6
APRIL	Possible											413.8
	Actual	172.8	187.7	188.1	183.5	181.3	185.8	213.6	240.1	220.1	Missing	197.0
MAY	Possible											452.6
	Actual	250.0	180.4	265.1	280.1	156.5	225.0	257.2	209.3	335.5	Missing	237.6
JUNE	Possible											458.2
	Actual	179.7	258.2	275.4	173.2	239.2	250.3	280.8	263.0	303.7	272.3	250.5
JULY	Possible											464.7
	Actual	281.2	228.0	280.3	264.8	294.7	329.4	306.5	257.7	294.0	288.7	287.4
AUGUST	Possible											432.1
	Actual	288.6	280.9	300.5	216.8	269.8	272.2	223.4	283.6	269.7	261.2	267.5
SEPTEMBER	Possible											374.5
	Actual	135.4	133.6	137.9	166.7	199.5	165.4	168.4	202.6	121.2	187.1	161.8
OCTOBER	Possible											342.3
	Actual	132.8	65.8	131.4	108.1	145.6	165.1	148.9	132.1	177.6	147.1	139.4
NOVEMBER	Possible											291.5
	Actual	76.2	63.6	79.0	53.8	71.0	79.1	97.2	120.8	34.1	111.2	78.7
DECEMBER	Possible											280.3
	Actual	90.6	76.2	40.9	63.1	39.6	63.0	67.7	67.4	103.7	65.2	68.6
YEARLY	Possible											4,461.6
	Actual											2,028.1

SOURCE: Royal Botanical Garden

HEATING DEGREE-DAYS (Base 18°C)

MONTH	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	MAX.	MIN.	MEAN 10 YEARS
JANUARY	686.2	824.2	796.2	717.6	676.4	705.5	641.8	829.1	922.7	886.7	922.7	641.8	782.6
FEBRUARY	582.3	633.5	634.1	721.4	702.2	680.0	602.7	579.6	667.6	792.5	792.5	579.6	661.5
MARCH	576.4	580.5	636.3	667.1	452.2	574.7	632.4	518.5	482.7	680.8	680.8	452.2	580.0
APRIL	323.1	322.5	383.5	428.8	348.4	320.9	430.6	308.1	311.6	394.7	430.6	308.1	360.0
MAY	191.2	169.8	181.3	128.0	218.1	236.3	94.5	215.9	119.1	180.8	236.3	94.5	173.5
JUNE	64.3	44.0	31.9	80.2	18.7	48.1	30.2	20.6	64.2	53.1	80.2	18.7	43.7
JULY	11.5	3.8	8.2	22.0	4.9	2.7	7.4	7.8	7.3	15.3	22.0	2.7	9.1
AUGUST	0.5	7.7	18.1	25.3	9.3	1.6	17.3	33.6	31.6	2.3	33.6	0.5	14.7
SEPTEMBER	74.7	65.9	61.5	76.4	103.3	130.8	141.3	121.1	75.2	90.8	141.3	61.5	94.1
OCTOBER	251.6	196.7	153.8	353.3	212.1	316.5	234.4	364.9	284.0	295.6	364.9	153.8	266.3
NOVEMBER	406.0	372.5	448.4	409.0	420.6	430.8	327.3	540.8	411.0	446.2	540.8	327.3	431.9
DECEMBER	674.2	630.0	566.5	618.1	570.9	600.5	671.7	780.7	672.1	631.9	780.7	566.5	652.6
YEARLY	3862.0	3880.1	3919.8	4326.4	3846.1	4049.4	3840.6	4329.7	4839.1	4390.7	5033.4	3207.2	4047.0

SOURCE: Environment Canada

COOLING DEGREE-DAYS (Base 18°C)

	1976	1977	1978	1979	MAX.	MIN.	MEAN 4 YEARS
JANUARY	00.0	00.0	00.0	00.0	00.0	00.0	00.0
FEBRUARY	00.0	00.0	00.0	00.0	00.0	00.0	00.0
MARCH	00.0	00.0	00.0	00.0	00.0	00.0	00.0
APRIL	06.8	02.3	00.0	00.0	06.8	00.0	02.3
MAY	00.0	34.3	23.5	11.4	34.3	00.0	17.3
JUNE	71.3	31.8	44.3	37.8	71.3	31.8	46.3
JULY	54.7	105.0	78.9	97.9	105.0	54.7	84.1
AUGUST	55.9	58.3	75.4	51.0	75.4	51.0	60.2
SEPTEMBER	18.1	19.7	18.1	19.7	19.7	18.1	18.9
OCTOBER	00.0	00.0	00.0	05.4	05.4	00.0	01.4
NOVEMBER	00.0	00.0	00.0	00.0	00.0	00.0	00.0
DECEMBER	00.0	00.0	00.0	00.0	00.0	00.0	00.0
YEARLY	206.8	261.4	240.2	223.2	317.9	155.6	230.5

SOLAR ALTITUDE AND AZIMUTH FOR 43° NORTH LATITUDE - HAMILTON

	0900 HOURS		1000 HOURS		1100 HOURS		1200 HOURS		1300 HOURS		1400 HOURS		1500 HOURS	
MONTHS	Solar ALT.°	Solar AZIM.°	Solar ALT.°	Solar AZIM.°	Solar ALT.°	Solar AZIM.°	Solar ALT.°	Solar AZIM.°	Solar ALT.°	Solar AZIM.°	Solar ALT.°	Solar AZIM.°	Solar ALT.°	Solar AZIM.°
JANUARY 21	14.6	136.6	21.2	149.7	25.9	164.4	27.0	180.0	25.9	195.6	21.2	210.3	14.6	223.4
FEBRUARY 21	22.3	131.3	29.6	145.6	34.5	162.0	36.2	180.0	34.5	198.0	29.6	214.4	22.3	228.7
MARCH 21	31.1	124.3	39.3	139.8	44.9	158.6	47.0	180.0	44.9	201.4	39.3	220.2	31.1	235.7
APRIL 21	40.1	115.2	49.3	131.4	56.0	153.0	58.6	180.0	56.0	207.0	49.3	228.6	40.1	244.8
May 21	46.0	107.0	55.9	123.0	63.8	146.6	67.0	180.0	63.8	213.4	55.9	237.0	46.0	253.0
JUNE 21	48.2	103.1	58.5	118.7	66.9	142.8	70.4	180.0	66.9	217.2	58.5	241.3	48.2	256.9
JULY 21	46.4	106.3	56.4	122.3	64.3	146.0	67.6	180.0	64.3	214.0	56.4	237.7	46.4	253.7
AUGUST 21	40.6	114.5	49.8	130.8	56.7	152.6	59.3	180.0	56.7	207.4	49.8	229.2	40.6	245.5
SEPTEMBER 21	31.1	124.3	39.3	139.8	44.9	158.6	47.0	180.0	44.9	201.4	39.3	220.2	31.1	235.7
OCTOBER21	22.6	131.1	29.9	145.5	34.8	162.0	36.5	180.0	34.8	198.0	29.9	214.5	22.6	228.9
NOVEMBER 21	14.8	136.5	21.4	149.6	25.7	164.3	27.2	180.0	25.7	195.7	21.4	210.4	14.8	223.5
DECEMBER 21	11.7	138.5	18.0	151.2	22.1	165.1	23.6	180.0	22.1	194.9	18.0	208.8	11.7	221.5

SOURCE: National Research Council of Canada

360° N 0°
270° W
E 90°
S 180°

NOTE · THE SOLAR AZIMUTH IS MEASURED FROM THE NORTH

SOIL TEMPERATURE °C AM - 10 CM BELOW GROUND SURFACE

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	MEAN
JANUARY				1.3	0.5	1.2	1.4	1.2	- 0.3	0.7	0.9
FEBRUARY				0.1	0.8	0.7	0.6	1.7	- 1.1	0.3	0.4
MARCH				- 0.2	3.3	1.9	1.2	3.0	1.0	- 0.2	1.5
APRIL				3.3	7.5	6.7	4.8	8.3	7.3	4.0	6.0
MAY				12.4	11.9	11.7	13.6	11.8	13.4	10.8	12.2
JUNE				17.1	19.0	17.1	19.1	18.6	17.6	17.1	17.9
JULY				21.1	22.1	19.9	21.4	20.3	21.3	20.3	20.9
AUGUST				20.8	21.9	20.5	21.0	20.3	20.8	20.7	20.9
SEPTEMBER				18.8	18.6	16.7	18.3	16.8	18.8	17.7	17.7
OCTOBER				11.2	13.8	10.8	12.7	10.7	12.2	12.3	12.0
NOVEMBER				6.2	.7.2	7.6	8.9	4.3	8.8	7.0	7.3
DECEMBER				2.4	3.1	2.9	3.1	0.7	3.4	2.5	2.6
YEARLY MEAN				9.5	10.8	9.8	10.3	9.8	10.3	9.5	10.0

SOURCE: Royal Botanical Gardens

PRECIPITATION: Rain is expressed in millimetres (mm).
Snow is expressed in centimetres (cm).
Total Precipitation is expressed in millimetres (mm).
(Rain plus water equivalent of snow.)

		1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	MEAN
JANUARY	Rainfall	59.2	8.9	6.4	18.8	24.4	39.4	46.0	17.9	Tr	28.4	25.0
	Snowfall	40.6	23.1	30.7	45.5	11.4	33.5	17.8	90.6	52.6	90.3	44.4
	Precipitation	99.8	30.2	35.1	57.7	37.6	71.6	64.8	92.8	48.1	122.1	66.0
FEBRUARY	Rainfall	0.0	7.4	45.0	3.3	22.4	30.0	36.8	39.1	23.4	Tr	21.1
	Snowfall	4.3	22.6	43.4	61.2	43.9	40.9	38.9	17.5	9.7	28.7	31.1
	Precipitation	4.3	29.5	87.4	61.2	64.3	68.6	76.2	54.7	32.8	26.3	50.5
MARCH	Rainfall	32.8	36.6	9.1	73.9	114.6	58.3	44.7	116.1	63.6	50.9	57.6
	Snowfall	8.9	14.2	46.2	24.4	18.3	22.9	35.8	32.3	31.6	8.9	24.4
	Precipitation	41.7	52.8	55.6	97.5	132.6	80.5	86.9	151.7	95.3	59.9	83.4
APRIL	Rainfall	108.2	76.0	23.1	54.4	66.8	74.2	23.6	92.0	73.9	51.6	64.3
	Snowfall	5.1	2.3	2.5	17.8	1.3	5.3	18.0	3.5	5.9	5.6	6.7
	Precipitation	113.3	78.2	25.7	71.9	67.6	82.3	45.7	95.5	79.8	58.4	71.0
MAY	Rainfall	84.1	59.9	36.1	107.7	78.0	110.0	54.9	90.2	37.1	64.5	72.2
	Snowfall	-	-	-	-	-	Tr	-	Tr	Tr	-	0.0
	Precipitation	84.1	59.9	36.1	107.7	78.0	110.0	54.9	90.2	37.1	64.5	72.2
JUNE	Rainfall	57.2E	59.7	32.8	97.5	63.0	93.6	74.9	74.3	83.9	43.5	68.5
	Snowfall	-	-	-	-	-	-	-	-	-	-	0.0
	Precipitation	57.2E	59.7	32.8	97.5	63.0	93.6	74.9	74.3	83.9	43.5	68.5
JULY	Rainfall	77.0	103.6	54.4	54.6	73.4	52.1	87.1	83.5	76.4	42.1	70.4
	Snowfall	-	-	-	-	-	-	-	-	-	-	0.0
	Precipitation	77.0	103.6	54.4	54.6	73.4	52.1	87.1	83.5	76.4	42.1	70.4
AUGUST	Rainfall	4.6	46.7	97.6	150.4	8.4	6.9	150.9	61.7	87.3	67.0	68.0
	Snowfall	-	-	-	-	-	-	-	-	-	-	0.0
	Precipitation	14.6	46.7	97.6	150.4	8.4	6.9	150.9	61.7	87.3	67.0	68.0
SEPTEMBER	Rainfall	23.4	106.2	23.6	44.5	28.7	73.4	89.3	83.3	206.1	136.1	81.5
	Snowfall	-	-	-	-	-	-	-	-	-	-	0.0
	Precipitation	23.4	106.2	23.6	44.5	28.7	73.4	89.3	83.3	206.1	136.1	81.5
OCTOBER	Rainfall	70.6	64.0	53.9	80.3	164.6	25.4	50.0	57.6	39.0	70.5	68.4
	Snowfall	Tr	Tr	-	0.8	-	Tr	-	Tr	Tr	-	0.8
	Precipitation	70.6	64.0	53.9	80.3	164.6	25.4	50.0	57.6	39.0	70.5	69.6
NOVEMBER	Rainfall	61.0	49.3	18.0	42.9	104.7	73.2	53.2	15.3	63.3	51.6	53.3
	Snowfall	7.6	13.7	27.4	20.6	3.1	2.8	10.1	5.2	8.4	12.0	11.1
	Precipitation	68.6	62.0	40.8	67.1	108.6	76.5	66.4	20.0	69.2	62.6	65.1
DECEMBER	Rainfall	18.0	20.2	70.6	67.1	37.8	12.5	34.3	10.0	63.7	51.8	39.5
	Snowfall	68.6	76.0	33.0	41.7	48.5	50.8	60.3	40.7	66.4	19.0	50.5
	Precipitation	87.4	96.3	105.7	108.2	87.6	59.2	92.8	42.9	135.6	77.5	89.4
YEARLY	Rainfall											689.8
	Snowfall											169.0
	Precipitation											856.4

Tr = Trace - Negligible amount of rain or snow. E = Estimated.

SOURCE: Environment Canada.

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION (AVERAGE 1976 – 1979).

	NORTH		NNE		NE		ENE		EAST		ESE		SE		SSE		SOUTH		SSW		SW		WSW		WEST		WNW		NW		NNW	
JANUARY	16	18	21	33	22	31	25	48	21	25	17	6	11	3	11	6	17	9	25	50	22	89	27	161	25	130	22	48	21	32	15	23
FEBRUARY	14	33	16	33	24	24	21	41	15	16	10	6	11	7	11	7	12	22	19	44	21	80	24	118	25	131	21	46	19	36	17	17
MARCH	17	11	16	16	21	71	22	78	14	30	11	9	13	10	16	17	16	34	22	50	25	74	24	106	24	120	23	62	21	28	14	12
APRIL	16	38	18	35	23	84	23	65	13	22	12	7	9	4	11	10	16	28	17	38	22	66	23	57	23	102	24	63	21	50	19	33
MAY	15	27	19	49	19	120	19	49	13	19	10	7	12	8	15	21	14	68	15	55	19	62	18	51	17	71	19	49	19	36	17	24
JUNE	12	29	14	36	16	64	14	29	10	20	10	10	10	10	14	23	16	58	18	78	19	76	17	52	17	89	18	65	17	38	14	16
JULY	12	31	14	30	15	54	15	31	9	10	8	5	9	3	11	11	14	62	15	94	16	101	15	81	15	86	17	52	17	44	16	26
AUGUST	11	27	12	33	13	65	13	55	11	22	8	7	8	3	9	7	12	37	16	70	16	102	17	81	15	92	15	50	14	49	11	27
SEPTEMBER	10	35	13	35	15	68	16	83	10	26	10	8	9	7	12	15	11	36	16	58	16	80	17	73	17	76	17	40	16	32	15	28
OCTOBER	15	35	15	43	18	70	15	43	13	20	11	9	13	8	14	17	18	50	20	60	19	87	22	86	18	83	18	50	16	35	18	28
NOVEMBER	15	12	14	26	17	46	16	52	13	30	12	3	14	5	14	8	17	48	20	73	19	74	22	154	22	95	19	32	17	22	13	14
DECEMBER	18	19	14	19	18	23	18	50	14	34	11	4	11	8	15	10	17	19	21	56	25	98	26	184	23	110	22	45	20	32	17	14
YEARLY (AVG. SPEED - TOTAL HRS.)	14-315		16-378		18-720		18624		13274		12-81		11-76		13-152		15-471		19-726		20989		21-1204		20-1185		20-602		18-434		16-262	
	NORTH		NNE		NE		ENE		EAST		ESE		SE		SSE		SOUTH		SSW		SW		WSW		WEST		WNW		NW		NNW	

SUNRISE AND SUNSET

MONTH	SUNRISE	SUNSET
JANUARY 21	7:46	17:18
FEBRUARY 21	7:11	17:58
MARCH 21	6:24	18:32
APRIL 21	5:31	19:09
MAY 21	4:52	19:41
JUNE 21	4:41	20:02
JULY 21	4:58	19:54
AUGUST 21	5:31	19:14
SEPTEMBER 21	6:05	18:21
OCTOBER 21	6:40	17:30
NOVEMBER 21	7:18	16:52
DECEMBER 21	7:48	16:48

- All times in Eastern Standard Time.
- For Daylight Saving Time: From last Sunday of April to last Sunday of October, add one hour.

VALUES OF GLOBAL SOLAR RADIATION (MJm⁻²h⁻¹)

Station		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Trout Lake (4 Yrs. Record)	max.	.17	.51	.58	.83	.87	.89	.85	.72	[illegible]	.27	.15	.11
	avg.	.16	.33	.55	.79	.82	.76	.80	.67	.39	.24	.14	.12
	min.	.16	.32	.51	.74	.75	.64	.71	.64	.37	.19	.11	.10
Guelph (10 Yrs. Record)	max.	.3	.47	.60	.78	.97	1.06	1.07	.88	.60	.5	.28	.23
	avg.	.25	.38	.50	.66	.88	.93	.92	.79	.60	.4	.21	.19
	min.	.18	.38	.46	.61	.80	.73	.76	.73	.48	.39	.16	.15
Toronto (30 Yrs. Record)	max.	.25	.41	.62	.79	.98	1.03	1.06	.87	.66	.48	.25	.21
	avg.	.19	.32	.48	.65	.79	.9	.91	.77	.59	.38	.19	.15
	min.	[illegible]	.25	.36	[illegible]	.62	[illegible]	.79	.67	.49	.29	.14	.1
Elora (6 Yrs. Record)	max.	.46	.44	.61	.79	.86	.93	.98	.79	.66	.43	.21	.19
	avg.	.24	.38	.53	.72	.70	.87	.91	.77	.54	.36	.18	.17
	min.	.23	.33	.6	.64	.63	.78	.79	.72	.46	.29	.15	.14
Moosonee (13 Yrs. Record)	max.	.19	.44	.58	.85	.80	.96	.83	.72	.53	.32	.17	.15
	avg.	.18	.33	.54	.7	.76	.84	.77	.64	.45	.25	.14	.13
	min.	.15	.29	.47	.59	.64	.75	.68	.52	.42	.21	.11	.12
Kapuskasing (14 Yrs. Record)	max.	.28	.41	.67	.83	.88	1.15	.96	.8	.59	.36	.19	.18
	avg.	.19	.32	.55	.69	.76	.91	.85	.69	.49	.29	.15	.14
	min.	.14	.28	.46	.53	.64	.80	.76	.61	.29	.22	.12	.12
Ottawa (24 Yrs. Record)	max.	.32	.45	.60	.77	.95	1.05	1.01	.87	.67	.49	.28	.24
	avg.	.24	.38	.57	.69	.83	.9	.9	.77	.57	.37	.19	.18
	min.	.19	.31	.41	.59	.63	.72	.76	.45	.45	.28	.15	.14

Source: Environment Canada

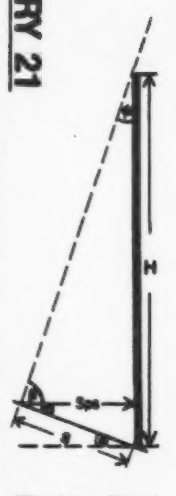
Note: Data for Hamilton is not available. The closest data station (Guelph) was selected for [illegible].

RELATIVE HUMIDITY PERCENTAGE

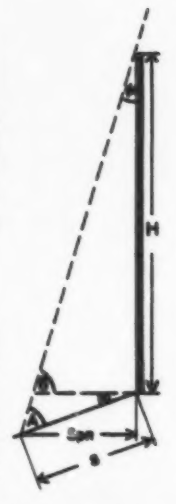
		1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	MEAN
JANUARY	8:00 a.m.	77	77	78	73	77	83	79	76	77	83	77
	7:00 p.m.	76	74	70	72	72	76	73	70	75	80	74
FEBRUARY	8:00 a.m.	73	74	74	73	77	73	80	78	75	84	76
	7:00 p.m.	70	70	73	71	74	72	77	75	76	75	73
MARCH	8:00 a.m.	68	75	73	72	87	79	76	77	81	82	77
	7:00 p.m.	65	68	70	72	77	71	74	74	74	74	72
APRIL	8:00 a.m.	70	73	68	70	73	72	67	73	71	69	70
	7:00 p.m.	62	61	58	62	64	60	62	64	65	60	63
MAY	8:00 a.m.	75	78	70	75	76	74	74	78	66	78	74
	7:00 p.m.	59	67	55	59	69	69	68	70	58	72	65
JUNE	8:00 a.m.	78	77	75	74	78	78	80	76	76	72	76
	7:00 p.m.	66	60	62	70	70	56	74	72	59	60	64
JULY	8:00 a.m.	77	86	75	78	78	76	73	82	78	79	78
	7:00 p.m.	62	72	65	65	65	51	67	74	65	64	65
AUGUST	8:00 a.m.	78	84	80	89	80	81	80	81	81	82	82
	7:00 p.m.	56	61	70	76	68	68	71	73	67	69	68
SEPTEMBER	8:00 a.m.	86	88	87	78	79	83	89	84	88	84	84
	7:00 p.m.	63	71	80	74	65	67	79	72	76	67	72
OCTOBER	8:00 a.m.	81	88	86	83	87	85	88	86	84	84	86
	7:00 p.m.	71	81	83	78	82	78	77	79	74	69	76
NOVEMBER	8:00 a.m.	84	86	81	82	82	87	86	79	86	84	83
	7:00 p.m.	78	79	76	79	81	81	83	71	81	80	79
DECEMBER	8:00 a.m.	81	80	79	82	78	86	81	75	82	83	80
	7:00 p.m.	79	78	78	82	77	82	78	76	81	79	80
YEARLY MEAN	8:00 a.m.	77	80	78	77	79	80	79	79	79	80	79
	7:00 p.m.	67	70	68	73	72	69	74	73	71	71	71

SOURCE: Environment Canada.

Date: JANUARY 21



(Southern Slope)



(Northern Slope)

FORMULA

$\angle A = \angle B \pm \angle \Theta$

$S = \frac{H \cdot \sin\Phi}{\sin A}$

Sps or Spn $= S \cdot \cos\Theta$

For Slopes h>5%

Sps or Spn $= \frac{100 \cdot S}{\sqrt{100^2 + h^2}}$

HOURS 05:00 & 19:00

Slope	Tang⁻¹	∠Θ	∠B	∠A=∠B±∠Θ	∠Φ	Sin Φ	Sin A	s. S=H·SinΦ/SinA	n.	CosΘ	Sps or Spn
0 %	0.00	0° 00' 00"									Sp
1 %	0.01	0° 34' 20"									Sps Spn
2 %	0.02	1° 08' 40"					N				Sps Spn
3 %	0.03	1° 43' 10"					A				Sps Spn
4 %	0.04	2° 17' 30"									Sps Spn
5 %	0.05	2° 51' 40"									Sps Spn

HOURS 06:00 & 18:00

Slope	Tang⁻¹	∠Θ	∠B	∠A=∠B±∠Θ	∠Φ	Sin Φ	Sin A	s. S=H·SinΦ/SinA	n.	CosΘ	Sps or Spn
0 %	0.00	0° 00' 00"									Sp
1 %	0.01	0° 34' 20"									Sps Spn
2 %	0.02	1° 08' 40"					N				Sps Spn
3 %	0.03	1° 43' 10"					A				Sps Spn
4 %	0.04	2° 17' 30"									Sps Spn
5 %	0.05	2° 51' 40"									Sps Spn

HOURS 07:00 & 17:00

Slope	Tang⁻¹	∠Θ	∠B	∠A=∠B±∠Θ	∠Φ	Sin Φ	Sin A	s. S=H·SinΦ/SinA	n.	CosΘ	Sps or Spn
0 %	0.00	0° 00' 00"									Sp
1 %	0.01	0° 34' 20"									Sps Spn
2 %	0.02	1° 08' 40"					N				Sps Spn
3 %	0.03	1° 43' 10"					A				Sps Spn
4 %	0.04	2° 17' 30"									Sps Spn
5 %.	0.05	2° 51' 40"									Sps Spn

HOURS 08:00 & 16:00

Slope	Tang⁻¹	∠Θ	∠B	∠A=∠B±∠Θ	∠Φ	Sin Φ	Sin A	s. S=H·SinΦ/SinA	n.	CosΘ	Sps or Spn
0 %	0.00	0° 00' 00"	6° 18'	6° 18' 0"	83° 42'	0.9939609	01097343	9.0578		1.0000000	Sp 9.058
1 %	0.01	0° 34' 20"	"	6 52 20	"	"	01196555	8.3084			Sps 8.306
				5 43 40			00998021		9.9593	0.9999501	Spn 9.959
2 %	0.02	1° 08' 40"	"	7 26 40	"	"	01295648	7.6715			Sps 7.670
				5 9 20			00896004		11.0932	0.9998005	Spn 11.091
3 %	0.03	1° 43' 10"	"	8 1 10	"	"	01395092	7.1286			Sps 7.122
				4 34 50			00798606		12.4461	0.9995497	Spn 12.441
4 %	0.04	2° 17' 30"	"	8 35 30	"	"	01493915	6.6539			Sps 6.648
				4 0 30			00699015		14.2194	0.9992002	Spn 14.208
5 %	0.05	2° 51' 40"	"	9 9 40	"	"	01592111	6.2430			Sps 6.235
				3 26 20			00599839		16.5704	0.9987535	Spn 16.545

HOURS 09:00 & 15:00

Slope	Tang⁻¹	∠Θ	∠B	∠A=∠B±∠Θ	∠Φ	Sin Φ	Sin A	s. S=H·SinΦ/SinA	n.	CosΘ	Sps or Spn
0 %	0.00	0° 00' 00"	14° 36'	14° 36' 00"	75° 24'	0.9677092	0.2520694	3.8390		1.0000000	Sp 3.839
1 %	0.01	0° 34' 20"	"	15 10 20	"	"	0.2617213	3.6974			Sps 3.697
				14 1 40			0.2423923		3.9923	0.9999501	Spn 3.992
2 %	0.02	1° 08' 40"	"	15 44 40	"	"	0.2713471	3.5663			Sps 3.566
				13 27 20			0.2326910		4.1588	0.9998005	Spn 4.158
3 %	0.03	1° 43' 10"	"	16 19 10	"	"	0.2809924	3.4439			Sps 3.442
				12 52 50			0.2229193		4.3411	0.9995497	Spn 4.340
4 %	0.04	2° 17' 30"	"	16 53 30	"	"	0.2905630	3.3305			Sps 3.328
				12 18 30			0.2131725		4.5396	0.9992002	Spn 4.536
5 %	0.05	2° 51' 40"	"	17 27 40	"	"	0.3000586	3.2251			Sps 3.221
				11 44 20			0.2034519		4.7564	0.9987535	Spn 4.750

HOURS 10:00 & 14:00

Slope	Tang⁻¹	∠Θ	∠B	∠A=∠B±∠Θ	∠Φ	Sin Φ	Sin A	s. S=H·SinΦ/SinA	n.	CosΘ	Sps or Spn
0 %	0.00	0° 00' 00"	21° 12'	21° 12' 00"	68° 48'	0.9323238	0.3616246	2.5782		1.0000000	Sp 2.578
1 %	0.01	0° 34' 20"	"	21 46 20	"	"	0.3709176	2.5162			Sps 2.516
				20 37 40			0.3522954		2.6464	0.9999501	Spn 2.646
2 %	0.02	1° 08' 40"	"	22 20 40	"	"	0.3801737	2.4524			Sps 2.452
				20 3 20			0.3429311		2.7187	0.9998005	Spn 2.718
3 %	0.03	1° 43' 10"	"	22 55 10	"	"	0.3894365	2.3940			Sps 2.393
				19 28 50			0.3334869		2.7957	0.9995497	Spn 2.794
4 %	0.04	2° 17' 30"	"	23 29 30	"	"	0.3986157	2.3389			Sps 2.337
				18 54 30			0.3240550		2.8770	0.9992002	Spn 2.875
5 %	0.05	2° 51' 40"	"	24 3 40	"	"	0.4077108	2.2867			Sps 2.284
				18 20 20			0.3146368		2.9632	0.9987535	Spn 2.953

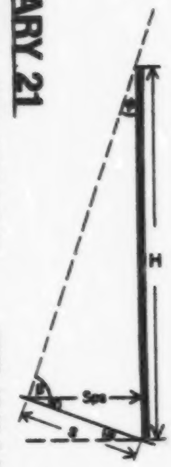
HOURS 11:00 & 13:00

Slope	Tang⁻¹	∠Θ	∠B	∠A=∠B±∠Θ	∠Φ	Sin Φ	Sin A	s. S=H·SinΦ/SinA	n.	CosΘ	Sps or Spn
0 %	0.00	0° 00' 00"	25° 30'	25° 30' 00"	64° 30'	0.9025853	0.4305111	2.0965		1.0000000	Sp 2.096
1 %	0.01	0° 34' 20"	"	26 4 20	"	"	0.4395037	2.0536			Sps 2.053
				24 55 40			0.4214755		2.1414	0.9999501	Spn 2.141
2 %	0.02	1° 08' 40"	"	26 38 40	"	"	0.4484525	2.0126			Sps 2.012
				24 21 20			0.4123979		2.1886	0.9998005	Spn 2.188
3 %	0.03	1° 43' 10"	"	27 13 10	"	"	0.4573597	1.9732			Sps 1.972
				23 46 50			0.4032547		2.2383	0.9995497	Spn 2.237
4 %	0.04	2° 17' 30"	"	27 47 30	"	"	0.4662579	1.9358			Sps 1.934
				23 12 30			0.3940755		2.2903	0.9992002	Spn 2.288
5 %	0.05	2° 51' 40"	"	28 21 40	"	"	0.4750270	1.9000			Sps 1.898
				22 38 20			0.3849218		2.3448	0.9987535	Spn 2.342

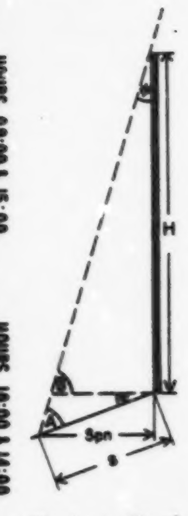
HOUR 12:00

Slope	Tang⁻¹	∠Θ	∠B	∠A=∠B±∠Θ	∠Φ	Sin Φ	Sin A	s. S=H·SinΦ/SinA	n.	CosΘ	Sps or Spn
0 %	0.00	0° 00' 00"	27° 00'	27° 00' 00"	63° 00'	0.8910065	0.4539905	1.9626		1.0000000	Sp 1.962
1 %	0.01	0° 34' 20"	"	27 34 20	"	"	0.4628663	1.9250			Sps 1.925
				26 25 40			0.4450694		2.0019	0.9999501	Spn 2.001
2 %	0.02	1° 08' 40"	"	28 8 40	"	"	0.4716960	1.8889			Sps 1.888
				25 51 20			0.4361039		2.0431	0.9998005	Spn 2.043
3 %	0.03	1° 43' 10"	"	28 43 10	"	"	0.4805211	1.8543			Sps 1.854
				25 16 50			0.4270510		2.0864	0.9995497	Spn 2.085
4 %	0.04	2° 17' 30"	"	29 17 30	"	"	0.4892556	1.8211			Sps 1.820
				24 42 30			0.4179992		2.1316	0.9992002	Spn 2.130
5 %	0.05	2 51' 40"	"	29 51 40	"	"	0.4978992	1.7895			Sps 1.787
				24 8 20			0.4089499		2.1788	0.9987535	Spn 2.176

Date: FEBRUARY 21



(Southern Slope)



(Northern Slope)

HOURS 05:00 & 18:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"									So
1 %	0.01	0° 34' 20"									Spe
											Spn
2 %	0.02	1° 08' 40"				N					Spe
											Spn
3 %	0.03	1° 43' 10"				A					Spe
											Spn
4 %	0.04	2° 17' 30"									Spe
											Spn
5 %	0.05	2° 51' 40"									Spe
											Spn

HOURS 06:00 & 18:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"									So
1 %	0.01	0° 34' 20"									Spe
											Spn
2 %	0.02	1° 08' 40"				N					Spe
											Spn
3 %	0.03	1° 43' 10"				A					Spe
											Spn
4 %	0.04	2° 17' 30"									Spe
											Spn
5 %	0.05	2° 51' 40"									Spe
											Spn

HOURS 07:00 & 17:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	3° 18'	3° 18' 00"	86° 41'	0.9983418	0.0575640	17.3432		1.0000000	So 17.343
1 %	0·01	0° 34' 20"	"	3 52 20	"	"	0.0675316	14.7833		0.9999501	Spe 13.999
				2 43 40			0.0475907		20.9777		Spn 20.976
2 %	0.02	1° 08' 40"	"	4 26 40	"	"	0.0774924	12.8831		0.9998005	Spe 12.880
				2 9 20			0.0376126		26.5427		Spn 26.537
3 %	0.03	1° 43' 10"	"	5 1 10	"	"	0.0874958	11.4104		0.9995497	Spe 11.405
				1 34 50			0.0275824		36.1949		Spn 36.179
4 %	0.04	2° 17' 30"	"	5 35 30	"	"	0.0974381	10.2459		0.9992002	Spe 10.238
				1 0 30			0.0175978		56.7311		Spn 56.686
5 %	0.05	2° 51' 40"	"	6 9 40	"	"	0.1073245	9.3021		0.9987535	Spe 9.290
				0 26 20			0.0076599		130.3335		Spn 130.171

HOURS 08:00 & 16:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	13° 24'	13° 24' 00"	76° 36'	0.9727758	0.2317479	4.1975		1.0000000	So 4.198
1 %	0.01	0° 34' 20"	"	13 58 20	"	"	0.2414514	4.0288		0.9999501	Spe 4.028
				12 49 40			0.2220212		4.3814		Spn 4.381
2 %	0.02	1° 08' 40"	"	14 32 40	"	"	0.2511309	3.8735		0.9998005	Spe 3.873
				12 15 20			0.2122724		4.7109		Spn 4.710
3 %	0.03	1° 43' 10"	"	15 7 10	"	"	0.2608321	3.7295		0.9995497	Spe 3.728
				11 40 50			0.2024550		4.8048		Spn 4.803
4 %	0.04	2° 17' 30"	"	15 41 30	"	"	0.2704604	3.5967		0.9992002	Spe 3.594
				11 6 30			0.1926647		5.0490		Spn 5.405
5 %	0.05	2° 51' 40"	"	16 15 40	"	"	0.2800152	3.4740		0.9987535	Spe 3.469
				10 32 20			0.1829029		5.3185		Spn 5.312

HOURS 09:00 & 15:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	22° 18'	22° 18' 00"	67° 42'	0.9252097	0.3794562	2.4383		1.0000000	So 2.438
1 %	0.01	0° 34' 20"	"	22 52 20	"	"	0.3886773	2.3804		0.9999501	Spe 2.380
				21 43 40			0.3701792		2.4992		Spn 2.499
2 %	0.02	1° 08' 40"	"	23 26 40	"	"	0.3978597	2.3255		0.9998005	Spe 2.320
				21 9 20			0.3609013		2.5636		Spn 2.563
3 %	0.03	1° 43' 10"	"	24 1 10	"	"	0.4070466	2.2730		0.9995497	Spe 2.272
				20 34 50			0.3515240		2.6320		Spn 2.631
4 %	0.04	2° 17' 30"	"	24 35 30	"	"	0.4161485	2.2233		0.9992002	Spe 2.222
				20 0 30			0.3421568		2.7040		Spn 2.702
5 %	0.05	2 51' 40"	"	25 9 40	"	"	0.4251651	2.1761		0.9987535	Spe 2.173
				19 26 20			0.3328013		2.7802		Spn 2.777

HOURS 10:00 & 14:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	29° 36'	29° 36' 00"	60° 24'	0.8694949	0.4939419	1.7603		1.0000000	So 1.760
1 %	0.01	0° 34' 20"	"	30 10 20	"	"	0.5026009	1.7300		0.9999501	Spe 1.729
				29 1 40			0.4852336		1.7919		Spn 1.792
2 %	0.02	1° 08' 40"	"	30 44 40	"	"	0.5112098	1.7009		0.9998005	Spe 1.701
				28 27 20			0.4764769		1.8248		Spn 1.824
3 %	0.03	1° 43' 10"	"	31 19 10	"	"	0.5198091	1.6727		0.9995497	Spe 1.672
				27 52 50			0.4676299		1.8593		Spn 1.858
4 %	0.04	2° 17' 30"	"	31 53 30	"	"	0.5283149	1.6458		0.9992002	Spe 1.644
				27 18 30			0.4587788		1.8952		Spn 1.894
5 %	0.05	2 51' 40"	"	32 27 40	"	"	0.5367270	1.6200		0.9987535	Spe 1.618
				26 44 20			0.4498253		1.9320		Spn 1.930

HOURS 11:00 & 13:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	34° 30'	34° 30' 00"	55° 30'	0.8241262	0.5664062	1.4550		1.0000000	So 1.455
1 %	0.01	0° 34' 20"	"	35 4 20	"	"	0.5746085	1.4342		0.9999501	Spe 1.434
				33 55 40			0.5581474		1.4765		Spn 1.476
2 %	0.02	1° 08' 40"	"	35 38 40	"	"	0.5827535	1.4141		0.9998005	Spe 1.414
				33 21 20			0.5498330		1.4988		Spn 1.498
3 %	0.03	1° 43' 10"	"	36 3 10	"	"	0.5885302	1.4003		0.9995497	Spe 1.399
				32 46 50			0.5414229		1.5221		Spn 1.521
4 %	0.04	2° 17' 30"	"	36 47 30	"	"	0.5988295	1.3762		0.9992002	Spe 1.375
				32 12 30			0.5329993		1.5462		Spn 1.545
5 %	0.05	2° 51' 40"	"	37 21 40	"	"	0.6068365	1.3580		0.9987535	Spe 1.356
				31 38 20			0.5245639		1.5710		Spn 1.569

HOUR 12:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	36° 12'	36° 12' 00"	53° 48'	0.8069603	0.5906057	1.3663		1.0000000	So 1.366
1 %	0.01	0° 34' 20"	"	36 46 20	"	"	0.5986353	1.3480		0.9999501	Spe 1.348
				35 37 40			0.5825171		1.3849		Spn 1.385
2 %	0.02	1° 08' 40"	"	37 20 40	"	"	0.6066053	1.3303		0.9998005	Spe 1.330
				35 3 20			0.5743704		1.4049		Spn 1.405
3 %	0.03	1° 43' 10"	"	37 55 10	"	"	0.6145530	1.3131		0.9995497	Spe 1.313
				34 28 50			0.5661265		1.4254		Spn 1.425
4 %	0.04	2° 17' 30"	"	38 29 30	"	"	0.6224008	1.2965		0.9992002	Spe 1.296
				33 54 30			0.5578658		1.4465		Spn 1.445
5 %	0.05	2° 51' 40"	"	39 3 40	"	"	0.6301489	1.2806		0.9987535	Spe 1.279
				33 20 20			0.5495900		1.4683		Spn 1.467

FORMULA

$\angle A = \angle B \pm \angle\theta$

$S = \frac{H\cdot\sin\Phi}{\sin A}$

Sps or Spn $= S\cdot\cos\theta$

For Slopes h>5%

Sps or Spn $= \frac{100\cdot S}{\sqrt{100^2+h^2}}$

Date: MARCH 21

HOURS 05:00 & 19:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. S=$\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"									So
1 %	0.01	0° 34' 20"									Sps Spn
2 %	0.02	1° 08' 40"				N					Sps Spn
3 %	0.03	1° 43' 10"				A					Sps Spn
4 %	0.04	2° 17' 30"									Sps Spn
5 %	0.05	2° 51' 40"									Sps Spn

HOURS 06:00 & 18:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. S=$\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"									So
1 %	0.01	0° 34' 20"									Sps Spn
2 %	0.02	1° 08' 40"				N					Sps Spn
3 %	0.03	1° 43' 10"				A					Sps Spn
4 %	0.04	2° 17' 30"									Sps Spn
5 %	0.05	2° 51' 40"									Sps Spn

HOURS 07:00 & 17:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. S=$\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	10° 54'	10° 54' 00"	79° 6'	0.9819587	0.1890954	5.1929275		1.0000000	So 5.192
1 %	0.01	0° 34' 20"	"	11 28 20 10 19 40	"	"	0.1988928 0.1792792	4.9371	5.4775	0.9999501	Sps 4.936 Spn 5.477
2 %	0.02	1° 08' 40"	"	12 2 40 9 45 20	"	"	0.2086703 0.1694450	4.7058	5.7951	0.9998005	Sps 4.705 Spn 5.798
3 %	0.03	1° 43' 10"	"	12 37 10 9 10 50	"	"	0.2184744 0.1595462	4.4946	6.1547	0.9995497	Sps 4.493 Spn 6.153
4 %	0.04	2° 17' 30"	"	13 11 30 8 36 30	"	"	0.2282092 0.1496791	4.3028	6.5604	0.9992002	Sps 4.296 Spn 6.555
5 %	0.05	2° 51' 40"	"	13 45 40 8 2 20	"	"	0.2378425 0.1398452	4.1286	7.0217	0.9987535	Sps 4.123 Spn 7.023

HOURS 08:00 & 16:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. S=$\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	21° 24'	21° 24' 00"	68° 36'	0.9310558	0.3648768	2.5517		1.0000000	So 2.552
1 %	0.01	0° 34' 20"	"	21 58 20 20 49 40	"	"	0.3741570 0.3555601	2.4884	2.6186	0.9999501	Sps 2.488 Spn 2.618
2 %	0.02	1° 08' 40"	"	22 32 40 20 15 20	"	"	0.3833989 0.3462080	2.4284	2.6893	0.9998005	Sps 2.428 Spn 2.689
3 %	0.03	1° 43' 10"	"	23 7 10 19 40 50	"	"	0.3926192 0.3367757	2.3712	2.7646	0.9995497	Sps 2.370 Spn 2.763
4 %	0.04	2° 17' 30"	"	23 41 30 19 6 30	"	"	0.4018146 0.3273553	2.3171	2.8442	0.9992002	Sps 2.315 Spn 2.842
5 %	0.05	2° 51' 40"	"	24 15 40 18 32 20	"	"	0.4108956 0.3179442	2.2659	2.9283	0.9987535	Sps 2.231 Spn 2.925

HOURS 09:00 & 15:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. S=$\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	31° 06'	31° 06' 00"	58° 54'	0.8562671	0.5165333	1.6577		1.0000000	So 1.657
1 %	0.01	0° 34' 20"	"	31 40 20 30 31 40	"	"	0.5250591 0.5079560	1.6308	1.6857	0.9999501	Sps 1.630 Spn 1.686
2 %	0.02	1° 08' 40"	"	32 14 40 29 57 20	"	"	0.5335325 0.4993281	1.6049	1.7148	0.9998005	Sps 1.605 Spn 1.714
3 %	0.03	1° 43' 10"	"	32 48 10 29 22 50	"	"	0.5419934 0.4906081	1.5798	1.7453	0.9995497	Sps 1.579 Spn 1.744
4 %	0.04	2° 17' 30"	"	33 23 30 28 48 30	"	"	0.5503593 0.4818811	1.5558	1.7769	0.9992002	Sps 1.554 Spn 1.776
5 %	0.05	2 51' 40"	"	33 57 40 28 14 20	"	"	0.5586301 0.4731488	1.5328	1.8097	0.9987535	Sps 1.530 Spn 1.807

HOURS 10:00 & 14:00

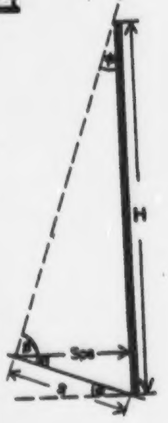
SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. S=$\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	39° 18'	39° 18' 00"	50° 42'	0.7738402	0.6333809	1.2218		1.0000000	So 1.221
1 %	0.01	0° 34' 20"	"	39 52 20 38 43 40	"	"	0.6410776 0.6256209	1.2071	1.2369	0.9999501	Sps 1.207 Spn 1.237
2 %	0.02	1° 08' 40"	"	40 26 40 38 9 20	"	"	0.6487108 0.6177985	1.1929	1.2526	0.9998005	Sps 1.193 Spn 1.252
3 %	0.03	1° 43' 10"	"	41 1 10 37 34 50	"	"	0.6563151 0.6098762	1.1791	1.2688	0.9995497	Sps 1.179 Spn 1.268
4 %	0.04	2° 17' 30"	"	41 35 30 37 0 50	"	"	0.6638179 0.6019312	1.1657	1.2856	0.9992002	Sps 1.164 Spn 1.285
5 %	0.05	2 51' 40"	"	42 9 40 36 26 20	"	"	0.6712176 0.5939651	1.1529	1.3028	0.9987535	Sps 1.152 Spn 1.301

HOURS 11:00 & 13:00

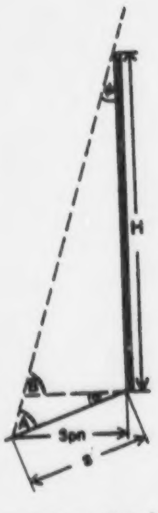
SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. S=$\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	44° 54'	44° 54' 00"	45° 6'	0.7083598	0.7058716	1.003497		1.0000000	So 1.003
1 %	0.01	0° 34' 20"	"	45 28 20 44 19 40	"	"	0.7129106 0.6987622	0.9936	1.0137	0.9999501	Sps 0.993 Spn 1.013
2 %	0.02	1° 08' 40"	"	46 02 40 43 45 20	"	"	0.7198784 0.6915431	0.9839	1.0242	0.9998005	Sps 0.983 Spn 1.024
3 %	0.03	1° 43' 10"	"	46 37 10 43 10 50	"	"	0.7268026 0.6842997	0.9746	1.0351	0.9995497	Sps 0.974 Spn 1.034
4 %	0.04	2° 17' 30"	"	47 11 30 42 36 30	"	"	0.7336310 0.6769430	0.9655	1.0463	0.9992002	Sps 0.964 Spn 1.045
5 %	0.05	2° 51' 40"	"	47 45 40 42 2 20	"	"	0.7403485 0.6696398	0.9568	1.0578	0.9987535	Sps 0.955 Spn 1.056

HOUR 12:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. S=$\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	47° 00'	47° 00' 00"	43° 00'	0.6819984	0.7313537	0.9325		1.0000000	So 0.932
1 %	0.01	0° 34' 20"	"	47 34 20 46 25 40	"	"	0.7381283 0.7245061	0.9240	0.9413	0.9999501	Sps 0.924 Spn 0.941
2 %	0.02	1° 08' 40"	"	48 8 40 45 51 10	"	"	0.7448294 0.7175863	0.9156	0.9504	0.9998005	Sps 0.915 Spn 0.950
3 %	0.03	1° 43' 10"	"	48 43 10 45 16 50	"	"	0.7514881 0.7105607	0.9075	0.9598	0.9995497	Sps 0.907 Spn 0.959
4 %	0.04	2° 17' 30"	"	49 17 30 44 42 30	"	"	0.7580395 0.7033987	0.8997	0.9696	0.9992002	Sps 0.899 Spn 0.969
5 %	0.05	2° 51' 40"	"	49 51 40 44 8 20	"	"	0.7644850 0.6962001	0.8921	0.9793	0.9987535	Sps 0.891 Spn 0.978



(Southern Slope)



(Northern Slope)

FORMULA

$\angle A = \angle B \pm \angle\theta$

$S = \frac{H\cdot \sin\Phi}{\sin A}$

Sps or Spn
$= S \cdot \cos\theta$

For Slopes h>5%

Sps or Spn
$= \frac{100\cdot S}{\sqrt{100^2+h^2}}$

Date: APRIL 21

HOURS 05:00 & 19:00

	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	Sin Φ	Sin A	a. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cos θ	Spe or Spn
0 %	0.00	0° 00' 00"									
1 %	0.01	0° 34' 20"									
2 %	0.02	1° 08' 40"				N					
3 %	0.03	1° 43' 10"				A					
4 %	0.04	2° 17' 30"									
5 %	0.05	2° 51' 40"									

HOURS 06:00 & 18:00

	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	Sin Φ	Sin A	a. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cos θ	Spe or Spn
0 %	0.00	0° 00' 00"	7° 54'	7° 54' 00"	82° 6'	0.9905095	0.1374445	7.2066		1.0000000	Sp 7.206
1 %	0.01	0° 34' 20"	"	8 28 20 7 19 40	"	"	0.1473299 0.1275454	6.7231	7.7659	0.9999501	Spe 6.722 Spn 7.766
2 %	0.02	1° 08' 40"	"	9 2 40 6 45 20	"	"	0.1572006 0.1176337	6.3009	8.4203	0.9998005	Spe 6.299 Spn 8.419
3 %	0.03	1° 43' 10"	"	9 37 10 6 10 50	"	"	0.1671034 0.1076620	5.9275	9.2083	0.9995497	Spe 5.925 Spn 9.204
4 %	0.04	2° 17' 30"	"	10 11 13 5 36 47	"	"	0.1768605 0.0980967	5.6005	10.0972	0.9992002	Spe 5.596 Spn 10.089
5 %	0.05	2° 51' 40"	"	10 45 40 5 2 20	"	"	0.1867146 0.0878319	5.3049	11.2773	0.9987535	Spe 5.298 Spn 11.263

HOURS 07:00 & 17:00

	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	Sin Φ	Sin A	a. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cos θ	Spe or Spn
0 %	0.00	0° 00' 00"	18° 48'	18° 48' 00"	71° 12'	0.9466493	0.3222657	2.9374		1.0000000	Sp 2.937
1 %	0.01	0° 34' 20"	"	19 22 20 18 13 40	"	"	0.3317058 0.3127954	2.8539	3.0264	0.9999501	Spe 2.853 Spn 3.026
2 %	0.02	1° 08' 40"	"	19 56 40 17 39 20	"	"	0.3411088 0.3032940	2.7752	3.1212	0.9998005	Spe 2.774 Spn 3.230
3 %	0.03	1° 43' 10"	"	20 31 10 17 4 50	"	"	0.3506252 0.2937159	2.7006	3.2230	0.9995497	Spe 2.698 Spn 3.222
4 %	0.04	2° 17' 30"	"	21 5 30 16 30 30	"	"	0.3598611 0.2841548	2.6306	3.3314	0.9992002	Spe 2.628 Spn 3.329
5 %	0.05	2° 51' 40"	"	21 39 40 15 56 20	"	"	0.3691160 0.2746120	2.5646	3.4472	0.9987535	Spe 2.561 Spn 3.443

HOURS 08:00 & 16:00

	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	Sin Φ	Sin A	a. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cos θ	Spe or Spn
0 %	0.00	0° 00' 00"	29° 42'	29° 42' 00"	60° 18'	0.8686315	0.4954587	1.7532		1.0000000	Sp 1.753
1 %	0.01	0° 34' 20"	"	30 16 20 29 7 40	"	"	0.5041090 0.4867590	1.7231	1.7845	0.9999501	Spe 1.723 Spn 1.784
2 %	0.02	1° 08' 40"	"	30 50 40 28 33 20	"	"	0.5127080 0.4780107	1.6942	1.8172	0.9998005	Spe 1.694 Spn 1.816
3 %	0.03	1° 43' 10"	"	31 25 10 27 58 50	"	"	0.5212983 0.4691719	1.6663	1.8514	0.9995497	Spe 1.665 Spn 1.850
4 %	0.04	2° 17' 30"	"	31 59 30 27 24 30	"	"	0.5297959 0.4603289	1.6396	1.8869	0.9992002	Spe 1.638 Spn 1.885
5 %	0.05	2° 51' 40"	"	32 33 40 26 50 20	"	"	0.5381958 0.4514833	1.6139	1.9239	0.9987535	Spe 1.612 Spn 1.922

HOURS 09:00 & 15:00

	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	Sin Φ	Sin A	a. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cos θ	Spe or Spn
0 %	0.00	0° 00' 00"	40° 6'	40° 6' 00"	49° 54'	0.7648214	0.6441236	1.1875		1.0000000	Sp 1.187
1 %	0.01	0° 34' 20"	"	40 40 20 39 31 40	"	"	0.6517508 0.6364522	1.1737	1.2018	0.9999501	Spe 1.173 Spn 1.201
2 %	0.02	1° 08' 40"	"	41 14 40 38 57 20	"	"	0.6592729 0.6287174	1.1602	1.2166	0.9998005	Spe 1.160 Spn 1.216
3 %	0.03	1° 43' 10"	"	41 49 10 38 22 50	"	"	0.6667854 0.6208818	1.1472	1.2320	0.9995497	Spe 1.147 Spn 1.231
4 %	0.04	2° 17' 30"	"	42 23 30 37 48 30	"	"	0.6741950 0.6130220	1.1345	1.2478	0.9992002	Spe 1.134 Spn 1.247
5 %	0.05	2 51' 40"	"	42 57 40 37 14 20	"	"	0.6815018 0.6051386	1.1226	1.2640	0.9987535	Spe 1.121 Spn 1.262

HOURS 10:00 & 14:00

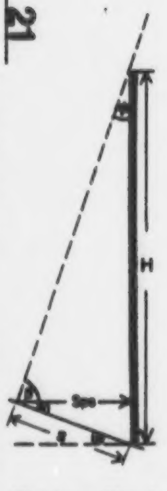
	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	Sin Φ	Sin A	a. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cos θ	Spe or Spn
0 %	0.00	0° 00' 00"	49° 27'	49° 27' 00"	40° 33'	0.6501114	0.7598388	0.8556		1.0000000	Sp 0.860
1 %	0.01	0° 34' 20"	"	50 1 20 48 52 40	"	"	0.7662937 [illegible]	[illegible]	0.8630	0.9999501	Spe [illegible] Spn [illegible]
2 %	0.02	1° 08' 40"	"	50 35 40 48 18 20	"	"	0.7726720 [illegible]	0.8414	0.8706	0.9998005	Spe 0.841 Spn 0.870
3 %	0.03	1° 43' 10"	"	51 10 10 47 43 50	"	"	[illegible] [illegible]	[illegible]	0.8785	0.9995497	Spe [illegible] Spn [illegible]
4 %	0.04	2° 17' 30"	"	51 44 30 47 9 30	"	"	0.7852269 [illegible]	0.8279	[illegible]	0.9992002	Spe 0.827 Spn [illegible]
5 %	0.05	2 51' 40"	"	52 18 40 [illegible]	"	"	0.7913931 [illegible]	0.8215	[illegible]	0.9987535	Spe 0.820 Spn [illegible]

HOURS 11:00 & 13:00

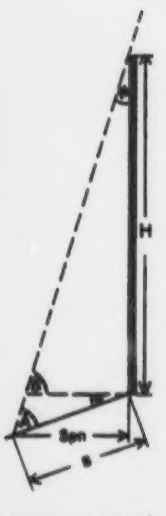
	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	Sin Φ	Sin A	a. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cos θ	Spe or Spn
0 %	0.00	0° 00' 00"	58° 0'	58° 00' 00"	34° 00'	0.5591929	0.8290375	0.6745		1.0000000	Sp 0.674
1 %	0.01	0° 34' 20"	"	56 34 20 55 25 40	"	"	[illegible] 0.8234116	0.6700	0.6791	0.9999501	Spe [illegible] Spn 0.679
2 %	0.02	1° 08' 40"	"	57 8 40 54 51 20	"	"	[illegible] 0.8177034	0.6655	0.6838	0.9998005	Spe 0.665 Spn 0.683
3 %	0.03	1° 43' 10"	"	57 43 10 54 16 50	"	"	[illegible] [illegible]	0.6614	[illegible]	0.9995497	Spe [illegible] Spn [illegible]
4 %	0.04	2° 17' 30"	"	58 17 30 53 42 30	"	"	0.8507347 [illegible]	0.6573	[illegible]	0.9992002	Spe 0.657 Spn [illegible]
5 %	0.05	2° 51' 40"	"	58 51 40 53 8 20	"	"	0.8559163 [illegible]	0.6533	[illegible]	0.9987535	Spe 0.652 Spn [illegible]

HOUR 12:00

	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	Sin Φ	Sin A	a. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cos θ	Spe or Spn
0 %	0.00	0° 00' 00"	58° 36'	58° 36' 00"	31° 24'	0.5210096	0.8535508	0.6104		1.0000000	Sp 0.610
1 %	0.01	0° 34' 20"	"	59 10 20 58 1 40	"	"	[illegible] [illegible]	0.6067	0.6139	0.9999501	Spe 0.607 Spn 0.614
2 %	0.02	1° 08' 40"	"	59 44 40 57 27 20	"	"	[illegible] [illegible]	0.6032	0.6181	0.9998005	Spe 0.603 Spn 0.618
3 %	0.03	1° 43' 10"	"	60 19 10 56 52 50	"	"	0.8687986 0.8375333	0.5997	0.6220	0.9995497	Spe 0.599 Spn 0.621
4 %	0.04	2° 17' 30"	"	60 53 30 56 18 30	"	"	0.8737015 0.8320348	0.5963	0.6262	0.9992002	Spe 0.596 Spn 0.625
5 %	0.05	2° 51' 40"	"	61 27 40 55 44 20	"	"	0.8784930 0.8264806	0.5931	0.6304	0.9987535	Spe 0.592 Spn 0.630



(Southern Slope)



(Northern Slope)

FORMULA

$\angle A = \angle B \pm \angle\theta$

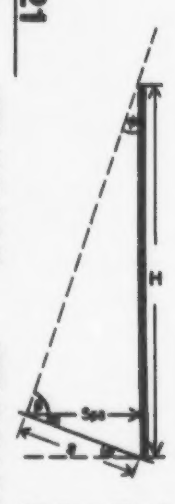
$S = \frac{H\cdot\sin\Phi}{\sin A}$

Spe or Spn $= S\cdot\cos\theta$

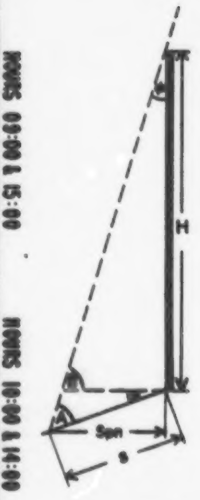
For Slopes h>5%

Spe or Spn $= \frac{100\cdot S}{\sqrt{100^2+h^2}}$

Date: MAY 21



(Southern Slope)



(Northern Slope)

FORMULA

$\angle A = \angle B \pm \angle \theta$

$S = \frac{H \cdot \sin \Phi}{\sin A}$

Sps or Spn $= S \cdot \cos\theta$

For Slopes h>5%

Sps or Spn $= \frac{100 \cdot S}{\sqrt{100^2 + h^2}}$

HOURS 05:00 & 19:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	Sin Φ	Sin A	s. S=H·SinΦ/Sin A	n.	Cos θ	Sps or Spn
0 %	0.00	0° 00' 00"	3° 12'	3° 23' 00"	86° 48'	0.9984408	0.0558215	17.8836		1.0000000	Sp 17.886
1 %	0.01	0° 34' 20"	"	3 46 20 2 37 40	"	"	0.0657301 0.0458475	15.1761	21.7775	0.9999501	Sps 15.175 Spn 21.776
2 %	0.02	1° 08' 40"	"	4 20 40 2 3 20	"	"	0.0757522 0.0358685	13.1805	27.8361	0.9998005	Sps 13.177 Spn 27.830
3 %	0.03	1° 43' 10"	"	4 55 10 1 28 50	"	"	0.0857550 0.0258377	11.6429	38.6428	0.9995497	Sps 11.637 Spn 38.625
4 %	0.04	2° 17' 30"	"	5 29 30 0 54 30	"	"	0.0957010 0.0158274	10.4329	63.0830	0.9992002	Sps 10.438 Spn 63.032
5 %	0.05	2° 51' 40"	"	6 3 40 0 20 20	"	"	0.1055892 0.0059147	9.45590	168.8067	0.9987535	Sps 9.444 Spn 168.593

HOURS 06:00 & 18:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	Sin Φ	Sin A	s. S=H·SinΦ/Sin A	n.	Cos θ	Sps or Spn
0 %	0.00	0° 00' 00"	13° 30'	13° 30' 00"	76° 30'	0.9723699	0.2334454	4.1653		1.0000000	Sp 4.165
1 %	0.01	0° 34' 20"	"	14 4 20 12 55 40	"	"	0.2431448 0.2237227	3.9991	4.3963	0.9999501	Sps 3.998 Spn 4.396
2 %	0.02	1° 08' 40"	"	14 38 40 12 21 20	"	"	0.2528199 0.2139777	3.8461	4.5442	0.9998005	Sps 3.845 Spn 4.543
3 %	0.03	1° 43' 10"	"	15 13 10 11 46 50	"	"	0.2625167 0.2041638	3.7040	4.7627	0.9995497	Sps 3.702 Spn 4.760
4 %	0.04	2° 17' 30"	"	15 47 30 11 12 30	"	"	0.2721403 0.1943770	3.5730	5.0025	0.9992002	Sps 3.570 Spn 4.998
5 %	0.05	2° 51' 40"	"	16 21 40 10 38 20	"	"	0.2816903 0.1846187	3.4519	5.2670	0.9987535	Sps 3.448 Spn 5.260

HOURS 07:00 & 17:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	Sin Φ	Sin A	s. S=H·SinΦ/Sin A	n.	Cos θ	Sps or Spn
0 %	0.00	0° 00' 00"	24° 18'	24° 18' 00"	65° 42'	0.9114033	0.4115144	2.21475		1.0000000	Sp 2.214
1 %	0.01	0° 34' 20"	"	24 52 20 23 43 40	"	"	0.4205590 0.4023916	2.1670	2.2649	0.9999501	Sps 2.166 Spn 2.264
2 %	0.02	1° 08' 40"	"	25 26 40 23 9 20	"	"	0.4296357 0.3932288	2.1213	2.3177	0.9998005	Sps 2.120 Spn 2.317
3 %	0.03	1° 43' 10"	"	26 1 10 22 34 50	"	"	0.4386761 0.3839820	2.0776	2.3735	0.9995497	Sps 2.077 Spn 2.372
4 %	0.04	2° 17' 30"	"	26 35 30 22 0 30	"	"	0.4476290 0.3747414	2.0361	2.4321	0.9992002	Sps 2.034 Spn 2.430
5 %	0.05	2° 51' 40"	"	27 9 40 21 26 20	"	"	0.4565490 0.3655076	1.9965	2.4935	0.9987535	Sps 1.994 Spn 2.490

HOURS 08:00 & 16:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	Sin Φ	Sin A	s. S=H·SinΦ/Sin A	n.	Cos θ	Sps or Spn
0 %	0.00	0° 00' 00"	35° 12'	35° 23' 00"	54° 48'	0.8171449	0.5764323	1.4176		1.0000000	Sp 1.417
1 %	0.01	0° 34' 20"	"	35 46 20 34 37 40	"	"	0.5845604 0.5682427	1.3978	1.4380	0.9999501	Sps 1.397 Spn 1.437
2 %	0.02	1° 08' 40"	"	36 20 40 34 3 20	"	"	0.5926352 0.5599865	1.3788	1.4592	0.9998005	Sps 1.378 Spn 1.458
3 %	0.03	1° 43' 10"	"	36 55 10 33 28 50	"	"	0.6006916 0.5516539	1.3603	1.4812	0.9995497	Sps 1.359 Spn 1.480
4 %	0.04	2° 17' 30"	"	37 29 30 32 54 30	"	"	0.6086463 0.5432965	1.3425	1.5040	0.9992002	Sps 1.341 Spn 1.503
5 %	0.05	2° 51' 40"	"	38 3 40 32 20 20	"	"	0.6165016 0.5349260	1.3254	1.5276	0.9987535	Sps 1.323 Spn 1.526

HOURS 09:00 & 15:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	Sin Φ	Sin A	s. S=H·SinΦ/Sin A	n.	Cos θ	Sps or Spn
0 %	0.00	0° 00' 00"	46° 00'	46° 00' 00"	44° 00'	0.6946584	0.7193398	0.9657		1.0000000	Sp 0.965
1 %	0.01	0° 34' 20"	"	46 34 20 45 25 40	"	"	0.7262415 0.7123464	0.9565	0.9751	0.9999501	Sps 0.956 Spn 0.975
2 %	0.02	1° 08' 40"	"	47 8 40 44 51 20	"	"	0.7330707 0.7053219	0.9476	0.9849	0.9998005	Sps 0.947 Spn 0.984
3 %	0.03	1° 43' 10"	"	47 43 10 44 16 50	"	"	0.7398595 0.6981724	0.9389	0.9950	0.9995497	Sps 0.939 Spn 0.995
4 %	0.04	2° 17' 30"	"	48 17 30 43 42 30	"	"	0.7465414 0.6909876	0.9305	1.0053	0.9992002	Sps 0.930 Spn 1.004
5 %	0.05	2 51' 40"	"	48 51 40 43 8 20	"	"	0.7531170 0.6837692	0.9224	1.0159	0.9987535	Sps 0.921 Spn 1.015

HOURS 10:00 & 14:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	Sin Φ	Sin A	s. S=H·SinΦ/Sin A	n.	Cos θ	Sps or Spn
0 %	0.00	0° 00' 00"	55° 54'	55° 54' 00"	34° 06'	0.5606390	0.8280603	0.6770		1.0000000	Sp 0.677
1 %	0.01	0° 34' 20"	"	56 28 20 55 19 40	"	"	0.8336181 0.8224198	0.6725	0.6817	0.9999501	Sps 0.672 Spn 0.682
2 %	0.02	1° 08' 40"	"	57 2 40 54 45 20	"	"	0.8390928 0.8166975	0.6681	0.6864	0.9998005	Sps 0.668 Spn 0.686
3 %	0.03	1° 43' 10"	"	57 37 10 54 10 50	"	"	0.8445097 0.8108653	0.6639	0.6914	0.9995497	Sps 0.664 Spn 0.691
4 %	0.04	2° 17' 30"	"	58 11 30 53 36 30	"	"	0.8498160 0.8049801	0.6597	0.6964	0.9992002	Sps 0.659 Spn 0.696
5 %	0.05	2 51' 40"	"	58 45 40 53 2 20	"	"	0.8550125 0.7990038	0.6557	0.7016	0.9987535	Sps 0.655 Spn 0.701

HOURS 11:00 & 13:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	Sin Φ	Sin A	s. S=H·SinΦ/Sin A	n.	Cos θ	Sps or Spn
0 %	0.00	0° 00' 00"	63° 48'	63° 48' 00"	26° 12'	0.4415058	0.8972583	0.4920		1.0000000	Sp 0.492
1 %	0.01	0° 34' 20"	"	64 22 20 63 13 40	"	"	0.9016229 0.8928083	0.4897	0.4945	0.9999501	Sps 0.489 Spn 0.494
2 %	0.02	1° 08' 40"	"	64 56 40 62 39 20	"	"	0.9058976 0.8882612	0.4874	0.4970	0.9998005	Sps 0.487 Spn 0.496
3 %	0.03	1° 43' 10"	"	65 31 10 62 4 50	"	"	0.9101020 0.8836058	0.4851	0.4996	0.9995497	Sps 0.484 Spn 0.499
4 %	0.04	2° 17' 30"	"	66 5 30 61 30 30	"	"	0.9141950 0.8788065	0.4829	0.5023	0.9992002	Sps 0.482 Spn 0.501
5 %	0.05	2° 51' 40"	"	66 39 40 60 56 20	"	"	0.9181777 0.8741021	0.4808	0.5051	0.9987535	Sps 0.480 Spn 0.504

HOUR 12:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	Sin Φ	Sin A	s. S=H·SinΦ/Sin A	n.	Cos θ	Sps or Spn
0 %	0.00	0° 00' 00"	67° 00'	67° 00' 00"	23° 00'	0.3907311	0.9205049	0.4245		1.0000000	Sp 0.424
1 %	0.01	0° 34' 20"	"	67 34 20 66 25 40	"	"	0.9243612 0.9165542	0.4227	0.4263	0.9999501	Sps 0.423 Spn 0.426
2 %	0.02	1° 08' 40"	"	68 8 40 65 51 20	"	"	0.9281253 0.9125172	0.4210	0.4282	0.9998005	Sps 0.421 Spn 0.428
3 %	0.03	1° 43' 10"	"	68 43 10 65 16 50	"	"	0.9318145 0.9083863	0.4193	0.4301	0.9995497	Sps 0.419 Spn 0.430
4 %	0.04	2° 17' 30"	"	69 17 30 64 42 30	"	"	0.9353926 0.9041467	0.4177	0.4321	0.9992002	Sps 0.417 Spn 0.432
5 %	0.05	2° 51' 40"	"	69 51 40 64 8 20	"	"	0.9388608 0.8998240	0.41676	0.4342	0.9987535	Sps 0.416 Spn 0.434

Date: JUNE 21

HOURS 05:00 & 19:00

Slope	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. S=H·SinΦ/SinA	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	5° 35'	5° 35' 00"	84° 24'	0.9952274	0.0975829	10.1988		1.0000000	So 10.198
1 %	0.01	0° 34' 20"	"	6 37 20 5 1	"	"	0.1153705 0.0876387	8.6264	11.3560	0.9999501	Sps 8.625 Spn 11.355
2 %	0.02	1° 08' 40"	"	6 48 40 4 27 20	"	"	0.1174411 0.0776858	8.4743	12.8109	0.9998005	Sps 8.472 Spn 12.808
3 %	0.03	1° 43' 10"	"	7 19 10 3 52 50	"	"	0.1274012 0.0676767	7.8116	14.7056	0.9995497	Sps 7.808 Spn 14.699
4 %	0.04	2° 17' 30"	"	7 53 30 3 18 50	"	"	0.1373005 0.0577092	7.2065	17.2455	0.9992002	Sps 7.203 Spn 17.232
5 %	0.05.	2° 51' 40"	"	8 27 40 2 44 20	"	"	0.1471381 0.0477884	6.7639	20.8274	0.9987535	Sps 6.755 Spn 20.801

HOURS 06:00 & 18:00

Slope	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. S=H·SinΦ/SinA	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	15° 42'	15° 42' 00"	72° 18'	0.9526615	0.2706004	3.5205		1.0000000	So 3.520
1 %	0.01	0° 34' 20"	"	16 16 20 15 7 40	"	"	0.2802013 0.2609725	3.3999	3.6504	0.9999501	Sps 3.399 Spn 3.650
2 %	0.02	1° 08' 40"	"	16 50 40 14 33 20	"	"	0.2897713 0.2513185	3.2876	3.7906	0.9998005	Sps 3.286 Spn 3.790
3 %	0.03	1° 43' 10"	"	17 25 10 13 58 50	"	"	0.2993[illegible] 0.2415926	3.1823	3.9133	0.9995497	Sps 3.180 Spn 3.911
4 %	0.04	2° 17' 30"	"	17 59 30 13 24 30	"	"	0.3088[illegible] 0.2318[illegible]	3.0862	4.1082	0.9992002	Sps 3.082 Spn 4.105
5 %	0.05	2° 51' 40"	"	18 33 40 12 50 20	"	"	0.3183159 0.2222105	2.9928	4.2872	0.9987535	Sps 2.989 Spn 4.282

HOURS 07:00 & 17:00

Slope	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. S=H·SinΦ/SinA	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	26° 24'	26° 24' 00"	63° 36'	0.8957117	0.4446352	2.0145		1.0000000	So 2.014
1 %	0·01	0° 34' 20"	"	26 58 20 25 49 40	"	"	0.4535807 0.4356675	1.9747	2.0560	0.9999501	Sps 1.974 Spn 2.055
2 %	0.02	1° 08' 40"	"	27 32 40 25 15 20	"	"	0.4624365 0.4266564	1.9370	2.0994	0.9998005	Sps 1.936 Spn 2.098
3 %	0.03	1° 43' 10"	"	28 7 10 24 40 50	"	"	0.4713112 0.4175587	1.9004	2.1451	0.9995497	Sps 1.899 Spn 2.144
4 %	0.04	2° 17' 30"	"	28 41 30 24 6 30	"	"	0.4800959 0.4084632	1.8657	2.1929	0.9992002	Sps 1.864 Spn 2.191
5 %	0.05	2° 51' 40"	"	29 15 40 23 32 20	"	"	0.4887904 0.3993714	1.8325	2.2428	0.9987535	Sps 1.830 Spn 2.240

HOURS 08:00 & 16:00

Slope	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. S=H·SinΦ/SinA	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	37° 24'	37° 24' 00"	52° 36'	0.7944146	0.6073758	1.3079		1.0000000	So 1.307
1 %	0.01	0° 34' 20"	"	37 58 20 36 49 40	"	"	0.6152798 0.5994117	1.2922	1.3253	0.9999501	Sps 1.291 Spn 1.325
2 %	0.02	1° 08' 40"	"	38 32 40 36 15 20	"	"	0.6231215 0.5913878	1.2749	1.3433	0.9998005	Sps 1.274 Spn 1.343
3 %	0.03	1°. 43' 10"	"	39 7 10 35 40 50	"	"	0.6309391 0.5832656	1.2591	1.3620	0.9995497	Sps 1.258 Spn 1.361
4 %	0.04	2° 17' 30"	"	39 41 30 35 6 30	"	"	0.6386559 0.5751282	1.2439	1.3813	0.9992002	Sps 1.243 Spn 1.380
5 %	0.05	2° 51' 40"	"	40 15 40 34 32 20	"	"	0.6462720 0.5669655	1.2105	1.4012	0.9987535	Sps 1.209 Spn 1.399

HOURS 09:00 & 15:00

Slope	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. S=H·SinΦ/SinA	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	48° 12'	48° 12' 00"	41° 48'	0.6665325	0.7454760	0.8941		1.0000000	So 0.894
1 %	0.01	0° 34' 20"	"	48 46 20 47 37 40	"	"	0.7520955 0.7387822	0.8862	0.9022	0.9999501	Sps 0.886 Spn 0.902
2 %	0.02	1° 08' 40"	"	49 20 40 47 3 20	"	"	0.7586399 0.7320146	0.8786	0.9105	0.9998005	Sps 0.878 Spn 0.910
3 %	0.03	1° 43' 10"	"	49 55 10 46 28 50	"	"	0.7651400 0.7251073	0.8711	0.9187	0.9995497	Sps 0.871 Spn 0.918
4 %	0.04	2° 17' 30"	"	50 29 30 45 54 30	"	"	0.7715321 0.7182275	0.8639	0.9280	0.9992002	Sps 0.863 Spn 0.927
5 %	0.05	2 51' 40"	"	51 3 40 45 20 20	"	"	0.7778167 0.7112767	0.8569	0.9371	0.9987535	Sps 0.857 Spn 0.936

HOURS 10:00 & 14:00

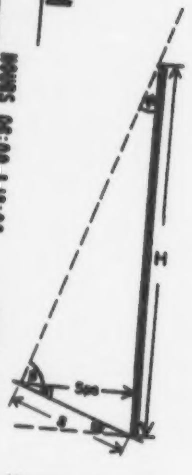
Slope	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. S=H·SinΦ/SinA	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	58° 30'	58° 30' 00"	31° 30'	0.5224986	0.8526402	0.6128		1.0000000	So 0.612
1 %	0.01	0° 34' 20"	"	59 4 20 57 55 40	"	"	0.8578158 0.8473795	0.6091	0.6166	0.9999501	Sps 0.609 Spn 0.617
2 %	0.02	1° 08' 40"	"	59 38 40 57 21 20	"	"	0.8629059 0.8420342	0.6055	0.6205	0.9998005	Sps 0.605 Spn 0.620
3 %	0.03	1° 43' 10"	"	60 13 10 56 46 50	"	"	0.8679341 0.8365786	0.6020	0.6246	0.9995497	Sps 0.601 Spn 0.624
4 %	0.04	2° 17' 30"	"	60 47 30 56 12 30	"	"	0.8728511 0.8310654	0.5986	0.6287	0.9992002	Sps 0.598 Spn 0.628
5 %	0.05	2 51' 40"	"	61 21 40 55 38 20	"	"	0.8776579 0.825[illegible]	0.5953	0.6329	0.9987535	Sps 0.594 Spn 0.632

HOURS 11:00 & 13:00

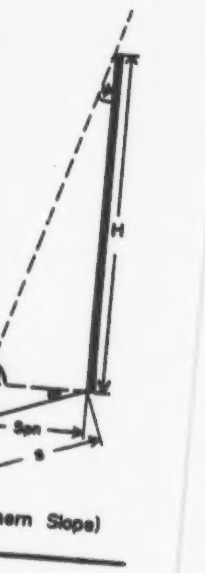
Slope	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. S=H·SinΦ/SinA	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	66° 54'	66° 54' 00"	23° 6'	0.3923371	0.9198215	0.4265		1.0000000	So 0.426
1 %	0.01	0° 34' 20"	"	67 28 20 66 19 40	"	"	0.9236939 0.9158574	0.4247	0.4283	0.9999501	Sps 0.424 Spn 0.428
2 %	0.02	1° 08' 40"	"	68 2 40 65 45 20	"	"	0.9274742 0.9118019	0.4230	0.4303	0.9998005	Sps 0.422 Spn 0.430
3 %	0.03	1° 43' 10"	"	68 37 10 65 10 50	"	"	0.9311796 0.9076351	0.4213	0.4323	0.9995497	Sps 0.421 Spn 0.432
4 %	0.04	2° 17' 30"	"	69 11 30 64 36 30	"	"	0.9347740 0.9033977	0.4197	0.4343	0.9992002	Sps 0.419 Spn 0.434
5 %	0.05	2° 51' 40"	"	69 45 40 64 2 20	"	"	0.9382580 0.89[illegible]	0.4182	0.4363	0.9987535	Sps 0.417 Spn 0.436

HOUR 12:00

Slope	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. S=H·SinΦ/SinA	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	70° 24'	70° 24' 00"	19° 36'	0.3354516	0.9420575	0.3561		1.0000000	So 0.356
1 %	0.01	0° 34' 20"	"	70 58 20 69 49 40	"	"	0.9453606 0.9386603	0.3548	0.3574	0.9999501	Sps 0.355 Spn 0.357
2 %	0.02	1° 08' 40"	"	71 32 40 69 15 20	"	"	0.9485695 0.9351696	0.3536	0.3587	0.9998005	Sps 0.353 Spn 0.358
3 %	0.03	1° 43' 10"	"	72 7 10 68 40 50	"	"	0.9516987 0.9315679	0.3525	0.3601	0.9995497	Sps 0.352 Spn 0.360
4 %	0.04	2° 17' 30"	"	72 41 30 68 6 30	"	"	0.9547175 0.9278905	0.3514	0.3615	0.9992002	Sps 0.351 Spn 0.361
5 %	0.05	2° 51' 40"	"	73 15 40 67 32 20	"	"	0.9576272 0.9241391	0.3503	0.3630	0.9987535	Sps 0.350 Spn 0.363



(Southern Slope)



(Northern Slope)

FORMULA

$\angle A = \angle B \pm \angle \theta$

$S = \frac{H \cdot \sin\Phi}{\sin A}$

Sps or Spn
$= S \cdot \cos\theta$

For Slopes h>5%

Sps or Spn

$= \frac{100 \cdot S}{\sqrt{100^2 + h^2}}$

Date: JULY 21

HOURS 05:00 & 19:00

SLOPE	Tang^{-1}	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H \cdot \text{Sin}\Phi}{\text{Sin} A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	3° 36'	3° 36' 00"	86° 24'	0.9980267	0.0627905	15.8945		1.0000000	Sp 15.984
1 %	0.01	0° 34' 20"	"	4 10 20	"	"	0.0727547	13.7177		0.9999501	Sps 13.717
				3 1 40			0.0528210		18.8945		Spn 18.893
2 %	0.02	1° 08' 40"	"	4 44 40	"	"	0.0827116	12.0663		0.9998005	Sps 12.064
				2 27 20			0.0428444		23.2942		Spn 23.289
3 %	0.03	1° 43' 10"	"	5 19 10	"	"	0.0927085	10.7652		0.9995497	Sps 10.760
				1 52 50			0.0328160		30.4128		Spn 30.399
4 %	0.04	2° 17' 30"	"	5 53 30	"	"	0.1026479	9.7228		0.9992002	Sps 9.715
				1 18 30			0.0228327		43.7104		Spn 43.675
5 %	0.05	2° 51' 40"	"	6 27 40	"	"	0.1125288	8.8690		0.9987535	Sps 8.858
				0 44 20			0.0128957		77.3922		Spn 77.296

HOURS 06:00 & 18:00

SLOPE	Tang^{-1}	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H \cdot \text{Sin}\Phi}{\text{Sin} A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	13° 54'	13° 54' 00"	76° 6'	0.9707165	0.2402280	4.0408		1.0000000	Sp 4.040
1 %	0.01	0° 34' 20"	"	14 28 20	"	"	0.2499106	3.8842		0.9999501	Sps 3.884
				13 19 40			0.2305215		4.2110		Spn 4.210
2 %	0.02	1° 08' 40"	"	15 2 40	"	"	0.2595682	3.7397		0.9998005	Sps 3.739
				12 45 20			0.2207920		4.3965		Spn 4.395
3 %	0.03	1° 43' 10"	"	15 37 10	"	"	0.2692467	3.6053		0.9995497	Sps 3.607
				12 10 50			0.2109931		4.6007		Spn 4.599
4 %	0.04	2° 17' 30"	"	16 11 30	"	"	0.2788514	3.4811		0.9992002	Sps 3.479
				11 36 30			0.2012208		4.8241		Spn 4.820
5 %	0.05	2° 51' 40"	"	16 45 40	"	"	0.2883820	3.3661		0.9987535	Sps 3.362
				11 2 20			0.1914752		5.0697		Spn 5.063

HOURS 07:00 & 17:00

SLOPE	Tang^{-1}	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H \cdot \text{Sin}\Phi}{\text{Sin} A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	24° 42'	24° 42' 00"	65° 18'	0.9085082	0.4178671	2.1741		1.0000000	Sp 2.174
1 %	0·01	0° 34' 20"	"	25 16 20	"	"	0.4269195	2.1280		0.9999501	Sps 2.127
				24 7 40			0.4087729		2.2225		Spn 2.222
2 %	0.02	1° 08' 40"	"	25 50 40	"	"	0.4359293	2.0841		0.9998005	Sps 2.083
				23 33 20			0.3996381		2.2733		Spn 2.272
3 %	0.03	1° 43' 10"	"	26 25 10	"	"	0.4449391	2.0419		0.9995497	Sps 2.040
				22 58 50			0.3904187		2.3271		Spn 2.326
4 %	0.04	2° 17' 30"	"	26 59 30	"	"	0.4538609	2.0017		0.9992002	Sps 2.000
				22 24 30			0.3812048		2.3833		Spn 2.381
5 %	0.05	2° 51' 40"	"	27 33 40	"	"	0.4626944	1.9635			Sps 1.961
				21 50 20			0.3719979		2.4422		Spn 2.439

HOURS 08:00 & 16:00

SLOPE	Tang^{-1}	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H \cdot \text{Sin}\Phi}{\text{Sin} A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	35° 36'	35° 36' 00"	54° 24'	0.8131007	0.5821229	1.3968		1.0000000	Sp 1.396
1 %	0.01	0° 34' 20"	"	36 10 20	"	"	0.5902144	1.3776		0.9999501	Sps 1.377
				35 1 40			0.5739735		1.4166		Spn 1.416
2 %	0.02	1° 08' 40"	"	36 44 40	"	"	0.5982069	1.3591		0.9998005	Sps 1.358
				34 27 20			0.5657668		1.4372		Spn 1.436
3 %	0.03	1° 43' 10"	"	37 19 10	"	"	0.6062583	1.3412		0.9995497	Sps 1.340
				33 52 50			0.5574634		1.4586		Spn 1.457
4 %	0.04	2° 17' 30"	"	37 53 30	"	"	0.6141708	1.3228		0.9992002	Sps 1.321
				33 18 30			0.5491444		1.4807		Spn 1.479
5 %	0.05	2° 51' 40"	"	38 27 40	"	"	0.6219833	1.3073		0.9987535	Sps 1.306
				32 44 20			0.5408113		1.5035		Spn 1.502

HOURS 09:00 & 15:00

SLOPE	Tang^{-1}	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H \cdot \text{Sin}\Phi}{\text{Sin} A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	46° 24'	46° 24' 00"	43° 36'	0.6896195	0.7241719	0.9522		1.0000000	Sp 0.952
1 %	0.01	0° 34' 20"	"	46 58 20	"	"	0.7310230	0.9437		0.9999501	Sps 0.944
				45 49 40			0.7172485		0.9615		Spn 0.961
2 %	0.02	1° 08' 40"	"	47 32 40	"	"	0.7378012	0.9347		0.9998005	Sps 0.935
				45 15 20			0.7102536		0.9709		Spn 0.971
3 %	0.03	1° 43' 10"	"	48 7 10	"	"	0.7445381	0.9262		0.9995497	Sps 0.926
				44 40 50			0.7031534		0.9807		Spn 0.980
4 %	0.04	2° 17' 30"	"	48 41 30	"	"	0.7511681	0.9181		0.9992002	Sps 0.917
				44 6 30			0.6960172		0.9908		Spn 0.990
5 %	0.05	2 51' 40"	"	49 15 40	"	"	0.7576916	0.9102		0.9987535	Sps 0.909
				43 32 20			0.6888468		1.0011		Spn 0.999

HOURS 10:00 & 14:00

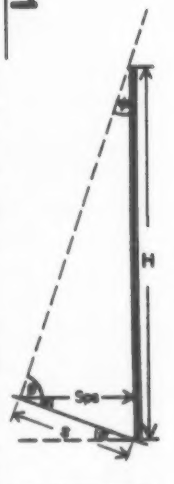
SLOPE	Tang^{-1}	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H \cdot \text{Sin}\Phi}{\text{Sin} A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	56° 24'	56° 24' 00"	33° 36'	0.5333915	0.8329212	0.6644		1.0000000	Sp 0.664
1 %	0.01	0° 34' 20"	"	56 58 20	"	"	0.8384064	0.6632		0.9999501	Sps 0.663
				55 49 40			0.8273530		0.6689		Spn 0.669
2 %	0.02	1° 08' 40"	"	57 32 40	"	"	0.8438080	0.6558		0.9998005	Sps 0.656
				55 15 20			0.8217022		0.6735		Spn 0.673
3 %	0.03	1° 43' 10"	"	58 7 10	"	"	0.8491510	0.6517		0.9995497	Sps 0.651
				54 40 50			0.8159418		0.6782		Spn 0.677
4 %	0.04	2° 17' 30"	"	58 41 30	"	"	0.8543833	0.6477		0.9992002	Sps 0.647
				54 6 30			0.8101269		0.6831		Spn 0.682
5 %	0.05	2 51' 40"	"	59 15 40	"	"	0.8595055	0.6438		0.9987535	Sps 0.643
				53 32 20			[illegible]		0.6880		Spn 0.687

HOURS 11:00 & 13:00

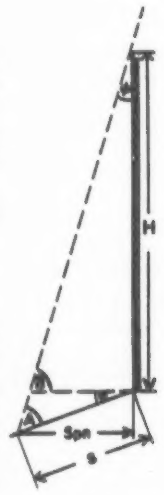
SLOPE	Tang^{-1}	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H \cdot \text{Sin}\Phi}{\text{Sin} A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	64° 18'	64° 18' 00"	25° 42'	0.4336591	0.9010770	0.4813		1.0000000	Sp 0.481
1 %	0.01	0° 34' 20"	"	64 52 20	"	"	0.9053630	0.4790		0.9999501	Sps 0.478
				63 43 40			0.8967011		0.4836		Spn 0.483
2 %	0.02	1° 08' 40"	"	65 26 40	"	"	0.9095587	0.4768		0.9998005	Sps 0.476
				63 9 20			0.8922358		0.4860		Spn 0.485
3 %	0.03	1° 43' 10"	"	66 1 10	"	"	0.9136834	0.4746		0.9995497	Sps 0.474
				62 34 50			0.8876592		0.4885		Spn 0.488
4 %	0.04	2° 17' 30"	"	66 35 30	"	"	0.9176968	0.4725		0.9992002	Sps 0.472
				62 0 30			0.8830158		0.4911		Spn 0.490
5 %	0.05	2° 51' 40"	"	67 9 40	"	"	0.9215999	0.4705		0.9987535	Sps 0.469
				61 26 20			0.8783077				Spn 0.493

HOUR 12:00

SLOPE	Tang^{-1}	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H \cdot \text{Sin}\Phi}{\text{Sin} A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	67° 36'	67° 36' 00"	22° 24'	0.3810704	0.9245460	0.4122		1.0000000	Sp 0.412
1 %	0.01	0° 34' 20"	"	68 10 20	"	"	0.9283057	0.4105		0.9999501	Sps 0.410
				67 1 40			0.9206942		0.4139		Spn 0.414
2 %	0.02	1° 08' 40"	"	68 44 40	"	"	0.9319727	0.4089		0.9998005	Sps 0.409
				66 27 20			0.9167505		0.4157		Spn 0.416
3 %	0.03	1° 43' 10"	"	69 19 10	"	"	0.9355639	0.4073		0.9995497	Sps 0.407
				65 52 50			0.9126956		0.4175		Spn 0.417
4 %	0.04	2° 17' 30"	"	69 53 30	"	"	0.9390443	0.4058		0.9992002	Sps 0.405
				65 18 30			0.9085699		0.4194		Spn 0.419
5 %	0.05	2° 51' 40"	"	70 27 40	"	"	0.9424147	0.4043		0.9987535	Sps 0.404
				64 44 20			0.9043724		0.4214		Spn 0.421



(Southern Slope)



(Northern Slope)

FORMULA

∠A = ∠B ± ∠θ

$S = \frac{H \cdot \text{Sin}\Phi}{\text{Sin} A}$

Sps or Spn
$= S \cdot \text{Cos}\theta$

For Slopes h>5%

Sps or Spn
$= \frac{100 \cdot S}{\sqrt{100^2 + h^2}}$

Date: AUGUST 21

HOURS 05:00 & 18:00

Slope	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	S=H·SinΦ/SinA a.	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"									Sp
1 %	0.01	0° 34' 20"									Sps
											Spn
2 %	0.02	1° 08' 40"				N					Sps
											Spn
3 %	0.03	1° 43' 10"				A					Sps
											Spn
4 %	0.04	2° 17' 30"									Sps
											Spn
5 %	0.05	2° 51' 40"									Sps
											Spn

HOURS 06:00 & 18:00

Slope	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	S=H·SinΦ/SinA a.	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	8° 24	8° 24' 00"	81° 36'	0.9892723	0.1460830	6.7720		1.0000000	Sp 6.772
1 %	0.01	0° 34' 20"	"	8 58 20	"	"	0.1559556	6.3433			Sps 6.382
				7 49 40			0.1361959		7.2636	0.9999501	Spn 7.263
2 %	0.02	1° 08' 40"	"	9 32 40	"	"	0.1658126	5.9662			Sps 5.965
				7 15 20			0.1262951		7.8330	0.9998005	Spn 7.831
3 %	0.03	1° 43' 10"	"	10 7 10	"	"	0.1757008	5.6304			Sps 5.628
				6 40 50			0.1163336		8.5036	0.9995497	Spn 8.499
4 %	0.04	2° 17' 30"	"	10 41 30	"	"	0.1855237	5.3323			Sps 5.328
				6 6 30			0.1064087		9.2969	0.9992002	Spn 9.289
5 %	0.05	2° 51' 40"	"	11 15 40	"	"	0.1952805	5.0659			Sps 5.059
				5 32 20			0.0965213		10.2492	0.9987535	Spn 10.247

HOURS 07:00 & 17:00

Slope	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	S=H·SinΦ/SinA a.	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	19° 18'	19° 18' 00"	70° 42'	0.9438009	0.3305144	2.8566		1.0000000	Sp 2.855
1 %	0.01	0° 34' 20"	"	19 52 20	"	"	0.3399236	2.7765			Sps 2.776
				18 43 40			0.3210722		2.9395	0.9999501	Spn 2.939
2 %	0.02	1° 08' 40"	"	20 26 40	"	"	0.3492910	2.7020			Sps 2.701
				18 9 20			0.3115979		3.0289	0.9998005	Spn 3.028
3 %	0.03	1° 43' 10"	"	21 1 10	"	"	0.3585847	2.6313			Sps 2.630
				17 34 50			0.3020964		3.1247	0.9995497	Spn 3.123
4 %	0.04	2° 17' 30"	"	21 35 30	"	"	0.3679893	2.5647			Sps 2.563
				17 0 30			0.2925108		3.2265	0.9992002	Spn 2.563
5 %	0.05	2° 51' 40"	"	22 9 40	"	"	0.3772122	2.5020			Sps 2.498
				16 26 20			0.2829925		3.3351	0.9987535	Spn 3.331

HOURS 08:00 & 16:00

Slope	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	S=H·SinΦ/SinA a.	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	30° 12'	30° 12' 00"	59° 48'	0.8642748	0.5030199	1.7182		1.0000000	Sp 1.718
1 %	0.01	0° 34' 20"	"	30 46 20	"	"	0.5116263	1.6893			Sps 1.689
				29 37 40			0.4943633		1.7482	0.9999501	Spn 1.748
2 %	0.02	1° 08' 40"	"	31 20 40	"	"	0.5201817	1.6615			Sps 1.661
				29 3 20			0.4856574		1.7796	0.9998005	Spn 1.779
3 %	0.03	1° 43' 10"	"	31 55 10	"	"	0.5287264	1.6346			Sps 1.633
				28 28 50			0.4768605		1.8124	0.9995497	Spn 1.811
4 %	0.04	2° 17' 30"	"	32 29 30	"	"	0.5371769	1.6089			Sps 1.607
				27 54 30			0.4680583		1.8465	0.9992002	Spn 1.845
5 %	0.05	2° 51' 40"	"	33 3 40	"	"	0.5455332	1.5842			Sps 1.587
				27 20 20			0.4592526		1.8819	0.9987535	Spn 1.879

HOURS 09:00 & 15:00

Slope	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	S=H·SinΦ/SinA a.	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	40° 35'	40° 35' 00"	49° 24'	0.7592713	0.6507742	1.1667		1.0000000	Sp 1.166
1 %	0.01	0° 34' 20"	"	41 10 20	"	"	0.6583246	1.1533			Sps 1.153
				40 0 40			0.6431589		1.1805	0.9999501	Spn 1.180
2 %	0.02	1° 08' 40"	"	41 44 40	"	"	0.6658093	1.1404			Sps 1.140
				39 27 20			0.6354795		1.1948	0.9998005	Spn 1.194
3 %	0.03	1° 43' 10"	"	42 19 10	"	"	0.6732635	1.1277			Sps 1.127
				38 52 50			0.6276989		1.2096	0.9995497	Spn 1.209
4 %	0.04	2° 17' 30"	"	42 53 30	"	"	0.6806143	1.1156			Sps 1.115
				38 18 30			0.6198933		1.2258	0.9992002	Spn 1.224
5 %	0.05	2° 51' 40"	"	43 27 40	"	"	0.6878621	1.1038			Sps 1.102
				37 44 20			0.6210639		1.2405	0.9987535	Spn 1.239

HOURS 10:00 & 14:00

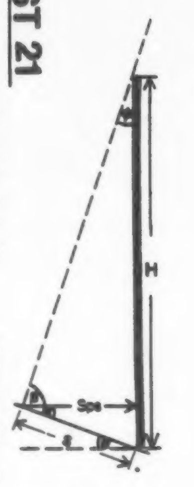
Slope	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	S=H·SinΦ/SinA a.	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	49° 48'	49° 48' 00"	40° 12'	0.6454577	0.7637960	0.8451		1.0000000	Sp 0.845
1 %	0.01	0° 34' 20"	"	50 22 20	"	"	0.7702041	0.8380			Sps 0.838
				49 13 40			0.7573118		0.8523	0.9999501	Spn 0.852
2 %	0.02	1° 08' 40"	"	50 56 40	"	"	0.7765354	0.8312			Sps 0.831
				48 39 20			0.7507519		0.8597	0.9998005	Spn 0.859
3 %	0.03	1° 43' 10"	"	51 31 10	"	"	0.7828194	0.8245			Sps 0.824
				48 4 50			0.7440849		0.8675	0.8675	Spn 0.867
4 %	0.04	2° 17' 30"	"	52 5 30	"	"	0.7889947	0.8181			Sps 0.817
				47 30 30			0.7473756		0.8253	0.9992002	Spn 0.825
5 %	0.05	2 51' 40"	"	52 39 40	"	"	0.7950620	0.8118			Sps 0.811
				46 56 20			0.7306259		0.8834	0.9987535	Spn 0.882

HOURS 11:00 & 13:00

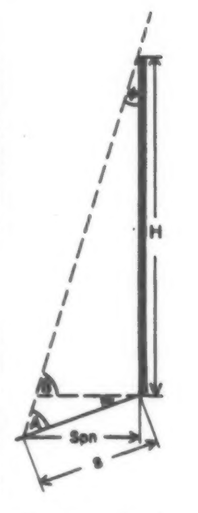
Slope	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	S=H·SinΦ/SinA a.	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	56° 42'	56° 42' 00"	33° 18'	0.5490228	0.8358074	0.6569		1.0000000	Sp 0.656
1 %	0.01	0° 34' 20"	"	57 16' 20"	"	"	0.8412487	0.6526			Sps 0.652
				56 7 40			0.8302826		0.6612	0.9999501	Spn 0.661
2 %	0.02	1° 08' 40"	"	57 50 40	"	"	0.8466062	0.6485			Sps 0.648
				55 33 20			0.8246750		0.6657	0.9998005	Spn 0.665
3 %	0.03	1° 43' 10"	"	58 25 10	"	"	0.8519047	0.6445			Sps 0.664
				54 58 50			0.8189573		0.6704	0.9995497	Spn 0.670
4 %	0.04	2° 17' 30"	"	58 59 30	"	"	0.8570924	0.6404			Sps 0.640
				54 24 30			0.8131854		0.6752	0.9992002	Spn 0.674
5 %	0.05	2 51' 40"	"	59 33 40	"	"	0.8621700	0.6368			Sps 0.636
				53 50 20			0.8073610		0.6800	0.9987535	Spn 0.679

HOUR 12:00

Slope	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	S=H·SinΦ/SinA a.	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	59°18'	59° 18' 00"	30° 42'	0.5105429	0.8498523	0.5938		1.0000000	Sp 0.593
1 %	0.01	0° 34' 20"	"	59 52 20	"	"	0.8649082	0.5903			Sps 0.590
				58 43 40			0.8547106		0.5973	0.9999501	Spn 0.597
2 %	0.02	1° 08' 40"	"	60 26 40	"	"	0.8698778	0.5869			Sps 0.587
				58 9 20			0.8494837		0.6010	0.9998005	Spn 0.601
3 %	0.03	1° 43' 10"	"	61 1 10	"	"	0.8747842	0.5836			Sps 0.583
				57 34 50			0.8441460		0.6048	0.9995497	Spn 0.605
4 %	0.04	2° 17' 30"	"	61 35 30	"	"	0.8795794	0.5804			Sps 0.580
				57 0 30			0.8387498		0.6087	0.9992002	Spn 0.608
5 %	0.05	2° 51' 40"	"	62 9 40	"	"	0.8842642	0.5774			Sps 0.608
				56 6 20			0.8332967		0.6127	0.9987535	Spn 0.612



(Southern Slope)



(Northern Slope)

FORMULA

$\angle A = \angle B \pm \angle \theta$

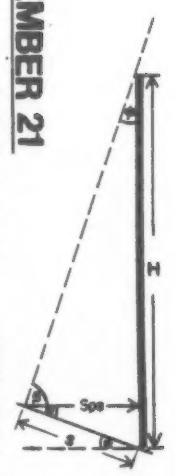
$S = \frac{H \cdot \sin\Phi}{\sin A}$

Sps or Spn $= S \cdot \cos\theta$

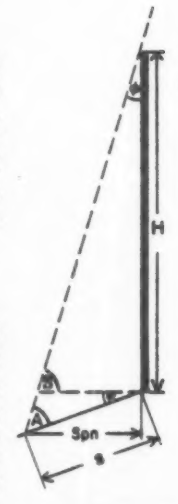
For Slopes h>5%

Sps or Spn $= \frac{100 \cdot S}{\sqrt{100^2 + h^2}}$

Date: SEPTEMBER 21



(Southern Slope)



(Northern Slope)

FORMULA

$\angle A = \angle B \pm \angle \theta$

$S = \frac{H \cdot Sin\Phi}{Sin A}$

Sps or Spn $= S \cdot Cos\theta$

For Slopes h>5%

Sps or Spn $= \frac{100 \cdot S}{\sqrt{100^2 + h^2}}$

HOURS 05:00 & 19:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H \cdot Sin\Phi}{Sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"									Sp
1 %	0.01	0° 34' 20"									Sps Spn
2 %	0.02	1° 08' 40"				N					Sps Spn
3 %	0.03	1° 43' 10"				A					Sps Spn
4 %	0.04	2° 17' 30"									Sps Spn
5 %	0.05	2° 51' 40"									Sps Spn

HOURS 06:00 & 18:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H \cdot Sin\Phi}{Sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"									Sp
1 %	0.01	0° 34' 20"									Sps Spn
2 %	0.02	1° 08' 40"				N					Sps Spn
3 %	0.03	1° 43' 10"				A					Sps Spn
4 %	0.04	2° 17' 30"									Sps Spn
5 %	0.05	2° 51' 40"									Sps Spn

HOURS 07:00 & 17:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H \cdot Sin\Phi}{Sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	10° 54'	10° 54' 00"	79° 6'	0.982958	0.1890954	5.1929		1.0000000	Sp 5.192
1 %	0·01	0° 34' 20"	〃	11 28 20	〃	〃	0.1988928	4.9371			Sps 4.936
				10 19 40			0.1792792		5.4773	0.9999501	Spn 5.477
2 %	0.02	1° 08' 40"	〃	12 2 40	〃	〃	0.2086704	4.7058			Sps 4.704
				9 45 20			0.1694451		5.7951	0.9998005	Spn 5.794
3 %	0.03	1° 43' 10"	〃	12 37 10	〃	〃	0.2184744	4.4986			Sps 4.493
				9 10 50			0.1595462		6.1547	0.9995497	Spn 6.152
4 %	0.04	2° 17' 30"	〃	13 11 30	〃	〃	0.2282093	4.3029			Sps 4.299
				8 36 30			0.1496791		6.5604	0.9992002	Spn 6.555
5 %	0.05	2° 51' 40"	〃	13 45 40	〃	〃	0.2378743	4.1281			Sps 4.123
				8 2 20			0.1398452		7.0217	0.9987535	Spn 7.013

HOURS 08:00 & 16:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H \cdot Sin\Phi}{Sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	21° 24'	21° 24' 00"	68° 35'	0.9310558	0.3648768	2.5517		1.0000000	Sp 2.551
1 %	0.01	0° 34' 20"	〃	21 58 20	〃	〃	0.3741570	2.4884			Sps 2.488
				20 49 40			0.3555601		2.6186	0.9999501	Spn 2.618
2 %	0.02	1° 08' 40"	〃	22 32 40	〃	〃	0.3833999	2.4284			Sps 2.427
				20 15 20			0.3462080		2.6893	0.9998005	Spn 2.688
3 %	0.03	1° 43' 10"	〃	23 7 10	〃	〃	0.3926492	2.3712			Sps 2.370
				19 40 50			0.3367757		2.7646	0.9995497	Spn 2.763
4 %	0.04	2° 17' 30"	〃	23 41 30	〃	〃	0.4018146	2.3171			Sps 2.318
				19 6 30			0.3273553		2.8442	0.9992002	Spn 2.842
5 %	0.05	2° 51' 40"	〃	24 15 40	〃	〃	0.4108956	2.2659			Sps 2.263
				18 32 20			0.3179482		2.9283	0.9987535	Spn 2.925

HOURS 09:00 & 15:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H \cdot Sin\Phi}{Sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	31° 6'	31° 6' 00"	58° 54'	0.8562671	0.8562671	1.6577		1.0000000	Sp 1.657
1 %	0.01	0° 34' 20"	〃	31 40 20	〃	〃	0.5250591	1.6308			Sps 1.631
				30 31 40			0.5079560		1.6857	0.9999501	Spn 1.686
2 %	0.02	1° 08' 40"	〃	32 14 40	〃	〃	0.5335325	1.6049			Sps 1.605
				29 57 20			0.4993281		1.7148	0.9998005	Spn 1.714
3 %	0.03	1° 43' 10"	〃	32 49 10	〃	〃	0.5419934	1.5799			Sps 1.579
				29 22 50			0.4906081		1.7453	0.9995497	Spn 1.745
4 %	0.04	2° 17' 30"	〃	33 23 30	〃	〃	0.5503593	1.5558			Sps 1.555
				28 48 30			0.4814811		1.7769	0.9992002	Spn 1.776
5 %	0.05	2 51' 40"	〃	33 47 40	〃	〃	0.5586301	1.5328			Sps 1.531
				28 14 20			0.4731488		1.8097	0.9987535	Spn 1.807

HOURS 10:00 & 14:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H \cdot Sin\Phi}{Sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	39° 18'	39° 18' 00"	50° 42'	0.7738402	0.6333809	1.2218		1.0000000	Sp 1.221
1 %	0.01	0° 34' 20"	〃	39 52 20	〃	〃	0.6410776	1.2071			Sps 1.207
				38 43 40			0.6256209		1.2369	0.9999501	Spn 1.236
2 %	0.02	1° 08' 40"	〃	40 26 40	〃	〃	0.6487104	1.1929			Sps 1.193
				38 9 20			0.6177986		1.2526	0.9998005	Spn 1.252
3 %	0.03	1° 43' 10"	〃	41 1 10	〃	〃	0.6563151	1.1791			Sps 1.179
				37 34 50			0.6098762		1.2689	0.9995497	Spn 1.268
4 %	0.04	2° 17' 30"	〃	41 35 30	〃	〃	0.6638174	1.1657			Sps 1.165
				37 0 30			0.6019312		1.2856	0.9992002	Spn 1.285
5 %	0.05	2 51' 40"	〃	42 9 40	〃	〃	0.6712176	1.1529			Sps 1.152
				36 26 20			0.5939651		1.3028	0.9987535	Spn 1.301

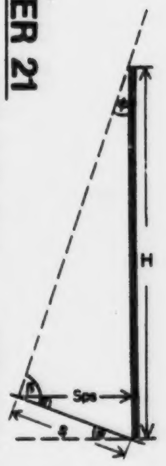
HOURS 11:00 & 13:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H \cdot Sin\Phi}{Sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	44° 54'	44° 54' 00"	45° 6'	0.7083398	0.7058716	1.0035		1.0000000	Sp 1.003
1 %	0.01	0° 34' 20"	〃	45 28 20	〃	〃	0.7129105	0.9936			Sps 0.993
				44 19 40			0.6987662		1.0137	0.9999501	Spn 1.013
2 %	0.02	1° 08' 40"	〃	46 2 40	〃	〃	0.7198784	0.9839			Sps 0.983
				43 45 20			0.6915831		1.0242	0.9998005	Spn 1.024
3 %	0.03	1° 43' 10"	〃	46 37 10	〃	〃	0.7268078	0.9746			Sps 0.974
				44 10 50			0.6842997		1.0351	0.9995497	Spn 1.034
4 %	0.04	2° 17' 30"	〃	47 11 30	〃	〃	0.7336310	0.9655			Sps 0.964
				42 35 30			0.6769830		1.0463	0.9992002	Spn 1.045
5 %	0.05	2° 51' 40"	〃	47 45 40	〃	〃	0.7403485	0.9567			Sps 0.955
				42 2 20			0.6696348		1.0578	0.9987535	Spn 1.565

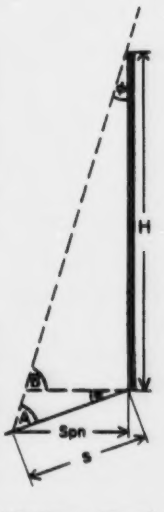
HOUR 12:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H \cdot Sin\Phi}{Sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	47° 00'	47° 00' 00"	43° 00'	0.6819984	0.7313537	0.9325		1.0000000	Sp 0.932
1 %	0.01	0° 34' 20"	〃	47 34 20	〃	〃	0.7381283	0.9240			Sps 0.924
				46 24 40			0.7245061		0.9413	0.9999501	Spn 0.941
2 %	0.02	1° 08' 40"	〃	48 8 40	〃	〃	0.7448294	0.9156			Sps 0.915
				45 51 20			0.7175863		0.9504	0.9998005	Spn 0.950
3 %	0.03	1° 43' 10"	〃	48 43 10	〃	〃	0.7514881	0.9075			Sps 0.907
				45 16 50			0.7105607		0.9598	0.9995497	Spn 0.959
4 %	0.04	2° 17' 30"	〃	49 17 30	〃	〃	0.7580395	0.8997			Sps 0.899
				44 42 30			0.7034981		0.9694	0.9992002	Spn 0.969
5 %	0.05	2° 51' 40"	〃	49 51 40	〃	〃	0.7644840	0.8921			Sps 0.891
				44 8 20			0.6964001		0.9793	0.9987535	Spn 0.978

Date: OCTOBER 21



(Southern Slope)



(Northern Slope)

FORMULA

$\angle A = \angle B \pm \angle \theta$

$S = \frac{H \cdot \sin\Phi}{\sin A}$

Sps or Spn $= S \cdot \cos\theta$

For Slopes h>5%

Sps or Spn $= \frac{100 \cdot S}{\sqrt{100^2 + h^2}}$

HOURS 05:00 & 19:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"									Sp
1 %	0.01	0° 34' 20"									Sps Spn
2 %	0.02	1° 08' 40"				N					Sps Spn
3 %	0.03	1° 43' 10"				A					Sps Spn
4 %	0.04	2° 17' 30"									Sps Spn
5 %	0.05	2° 51' 40"									Sps Spn

HOURS 06:00 & 18:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"									Sp
1 %	0.01	0° 34' 20"									Sps Spn
2 %	0.02	1° 08' 40"				N					Sps Spn
3 %	0.03	1° 43' 10"				A					Sps Spn
4 %	0.04	2° 17' 30"									Sps Spn
5 %	.0.05	2° 51' 40"									Sps Spn

HOURS 07:00 & 17:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	3° 30'	3° 30' 00"	86° 30'	0.9981348	0.0610485	16.3499		1.0000000	Sp 16.349
1 %	0.01	0° 34' 20"	"	4 4 20 2 55 40	"	"	0.0710386 0.0510771	14.0506	19.5417	0.9999501	Sps 14.049 Spn 19.540
2 %	0.02	1° 08' 40"	"	4 38 40 2 21 20	"	"	0.0809721 0.0411006	12.3269	24.2852	0.9998005	Sps 12.324 Spn 24.280
3 %	0.03	1° 43' 10"	"	5 13 10 1 46 50	"	"	0.0970548 0.0310755	10.2842	32.1196	0.9995497	Sps 10.279 Spn 32.105
4 %	0.04	2° 17' 30"	"	5 47 30 1 12 30	"	"	0.1009116 0.0210878	9.8912	47.3323	0.9992002	Sps 9.883 Spn 47.294
5 %	0.05	2° 51' 40"	"	6 21 40 0 38 20	"	"	0.1107944 0.0111504	9.0089	89.5149	0.9987535	Sps 8.997 Spn 89.403

HOURS 08:00 & 16:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	13° 36'	13° 36' 00"	76° 24'	0.9719610	0.2351421	4.1335		1.0000000	Sp 4.133
1 %	0.01	0° 34' 20"	"	14 10 20 13 1 40	"	"	0.2448373 0.2254234	3.9698	4.3117	0.9999501	Sps 3.969 Spn 4.311
2 %	0.02	1° 08' 40"	"	14 44 40 12 27 20	"	"	0.2545082 0.2156822	3.8289	4.5065	0.9998005	Sps 3.818 Spn 4.505
3 %	0.03	1° 43' 10"	"	15 19 10 11 52 50	"	"	0.2642004 0.2058721	3.6788	4.7210	0.9995497	Sps 3.677 Spn 4.719
4 %	0.04	2° 17' 30"	"	15 53 30 11 18 30	"	"	0.2718393 0.1968876	3.5755	4.9366	0.9992002	Sps 3.573 Spn 4.933
5 %	0.05	2° 51' 40"	"	16 27 40 10 44 20	"	"	0.2833645 0.1863335	3.4301	5.2162	0.9987535	Sps 3.426 Spn 5.209

HOURS 09:00 & 15:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	22° 36'	22° 36' 00"	67° 24'	0.9232102	0.3842953	2.4023		1.0000000	Sp 2.402
1 %	0.01	0° 34' 20"	"	23 10 20 22 10 40	"	"	0.3934963 0.3750561	2.3462	2.4615	0.9999501	Sps 2.345 Spn 2.461
2 %	0.02	1° 08' 40"	"	23 44 40 21 27 20	"	"	0.4026579 0.3657794	2.2928	2.5236	0.9998005	Sps 2.292 Spn 2.523
3 %	0.03	1° 43' 10"	"	24 19 10 20 52 50	"	"	0.4118236 0.3564209	2.2418	2.5902	0.9995497	Sps 2.241 Spn 2.589
4 %	0.04	2° 17' 30"	"	24 18 30 20 18 30	"	"	0.4209039 0.3470721	2.1934	2.6600	0.9992002	Sps 2.192 Spn 2.658
5 %	0.05	2 51' 40"	"	25 27 40 19 44 20	"	"	0.4298984 0.3377342	2.1475	2.7335	0.9987535	Sps 2.145 Spn 2.739

HOURS 10:00 & 14:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	29° 54'	29° 54' 00"	60° 6'	0.8668967	0.4984877	1.7391		1.0000000	Sp 1.739
1 %	0.01	0° 34' 20"	"	30 28 20 29 19 40	"	"	0.5071206 0.4898052	1.7094	1.7699	0.9999501	Sps 1.709 Spn 1.769
2 %	0.02	1° 08' 40"	"	31 2 40 28 45 20	"	"	0.5157028 0.4810738	1.6810	1.8020	0.9998005	Sps 1.681 Spn 1.802
3 %	0.03	1° 43' 10"	"	31 37 10 28 10 50	"	"	0.5242749 0.4722517	1.6535	1.8357	0.9995497	Sps 1.646 Spn 1.835
4 %	0.04	2° 17' 30"	"	32 1 30 27 36 30	"	"	0.5302892 0.4634249	1.6348	1.8706	0.9992002	Sps 1.634 Spn 1.869
5 %	0.05	2 51' 40"	"	32 45 40 27 2 20	"	"	0.5411376 0.4545952	1.6020	1.9060	0.9987535	Sps 1.600 Spn 1.904

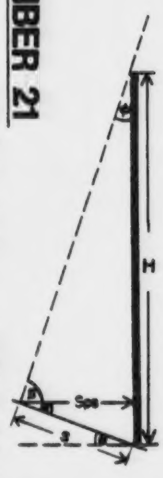
HOURS 11:00 & 13:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	34° 48'	34° 48' 00"	55° 12'	0.8211492	0.5707135	1.4388		1.0000000	Sp 1.438
1 %	0.01	0° 34' 20"	"	35 22 20 34 13 40	"	"	0.5788859 0.5624843	1.4185	1.4600	0.9999501	Sps 1.418 Spn 1.459
2 %	0.02	1° 08' 40"	"	35 56 40 33 39 20	"	"	0.5870005 0.5541989	1.3989	1.4817	0.9998005	Sps 1.398 Spn 1.481
3 %	0.03	1° 43' 10"	"	36 31 10 33 4 50	"	"	0.5950955 0.5458176	1.3799	1.5044	0.9995497	Sps 1.379 Spn 1.503
4 %	0.04	2° 17' 30"	"	37 5 30 32 30 30	"	"	0.6030920 0.5374222	1.3615	1.5279	0.999202	Sps 1.360 Spn 1.526
5 %	0.05	2° 51' 40"	"	37 39 40 31 56 20	"	"	0.6109898 0.5290144	1.3440	1.5518	0.9987535	Sps 1.342 Spn 1.549

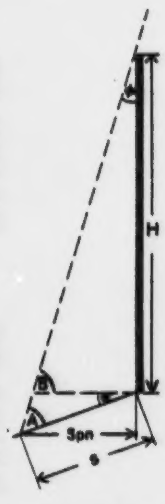
HOUR 12:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	Sin A	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	36° 30'	30° 30' 00"	53° 30'	0.8038569	0.5948228	1.3514		1.0000000	Sp 1.351
1 %	0.01	0° 34' 20"	"	37 3 20 35 55 40	"	"	0.6028212 0.5867650	1.3514	1.3700	0.9999501	Sps 1.351 Spn 1.370
2 %	0.02	1° 08' 40"	"	37 38 40 35 21 20	"	"	0.6107596 0.5786487	1.3162	1.3892	0.9998005	Sps 1.315 Spn 1.389
3 %	0.03	1° 43' 10"	"	35 13 10 34 46 50	"	"	0.6186751 0.5704349	1.2993	1.4092	0.9995497	Sps 1.298 Spn 1.409
4 %	0.04	2° 17' 30"	"	38 47 30 34 12 30	"	"	0.6264905 0.5622037	1.2831	1.4285	0.9992002	Sps 1.282 Spn 1.427
5 %	0.05	2° 51' 40"	"	39 21 40 33 38 20	"	"	0.6342059 0.5539568	1.2675	1.4511	0.9987535	Sps 1.266 Spn 1.449

Date: NOVEMBER 21



(Southern Slope)



(Northern Slope)

FORMULA

$\angle A = \angle B \pm \angle \theta$

$S = \frac{H \cdot \sin\Phi}{\sin A}$

Sps or Spn $= S \cdot \cos\theta$

For Slopes $h>5\%$

Sps or Spn $= \frac{100 \cdot S}{\sqrt{100^2+h^2}}$

HOURS 05:00 & 19:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"									Sp
1 %	0.01	0° 34' 20"									Sps Spn
2 %	0.02	1° 08' 40"					N				Sps Spn
3 %	0.03	1° ·43' 10"					A				Sps Spn
4 %	0.04	2° 17' 30"									Sps Spn
5 %	0.05.	2° 51' 40"									Sps Spn

HOURS 06:00 & 18:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"									Sp
1 %	0.01	0° 34' 20"									Sps Spn
2 %	0.02	1° 08' 40"					N				Sps Spn
3 %	0.03	1° 43' 10"					A				Sps Spn
4 %	0.04	2° 17' 30"									Sps Spn
5 %	0.05	2° 51' 40"									Sps Spn

HOURS 07:00 & 17:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"									Sp
1 %	0·01	0° 34' 20"									Sps Spn
2 %	0.02	1° 08' 40"					N				Sps Spn
3 %	0.03	1° 43' 10"					A				Sps Spn
4 %	0.04	2° 17' 30"									Sps Spn
5 %	0.05	2° 51' 40"									Sps Spn

HOURS 08:00 & 16:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	6° 30'	6° 30' 00"	83° 30'	0.9935718	0.1132032	8.7769		1.0000000	Sp 8.776
1 %	0.01	0° 34' 20"	"	7 4 20	"	"	0.1231204	8.0699			Sps 8.069
				5 55 40			0.1032747		9.6207	0.9999501	Spn 9.620
2 %	0.02	1° 08' 40"	"	7 38 40	"	"	0.1330252	7.4690			Sps 7.467
				5 21 20			0.0933360		10.6051	0.9998005	Spn 10.643
3 %	0.03	1° 43' 10"	"	8 13 10	"	"	0.1429648	6.9497			Sps 6.946
				4 46 50			0.0833966		11.9138	0.9995497	Spn 11.908
4 %	0.04	2° 17' 30"	"	8 47 30	"	"	0.1528421	6.5006			Sps 6.495
				4 12 30			0.0733832		13.5395	0.9992002	Spn 13.529
5 %	0.05	2° 51' 40"	"	9 21 40	"	"	0.1626563	6.1084			Sps 6.101
				3 38 20			0.0634679		15.6547	0.9987535	Spn 15.635

HOURS 09:00 & 15:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	14° 48'	14° 18' 00"	75° 12'	0.9668234	0.2554458	3.7848		1.0000000	Sp 3.784
1 %	0.01	0° 34' 20"	"	15 22 20	"	"	0.2650887	3.6472			Sps 3.647
				14 13 40			0.2457778		3.9337	0.9999501	Spn 3.934
2 %	0.02	1° 08' 40"	"	15 56 40	"	"	0.2747052	3.5195			Sps 3.519
				13 39 20			0.2360844		4.0952	0.9998005	Spn 4.094
3 %	0.03	1° 43' 10"	"	16 31 10	"	"	0.2843407	3.4002			Sps 3.399
				13 4 50			0.2263208		4.2719	0.9995497	Spn 4.270
4 %	0.04	2° 17' 30"	"	17 5 30	"	"	0.2939013	3.2896			Sps 3.287
				12 30 30			0.2165816		4.4640	0.9992002	Spn 4.599
5 %	0.05	2 51' 40"	"	17 39 40	"	"	0.3033864	3.1868			Sps 3.183
				11 56 20			0.2068683		4.6736	0.9987535	Spn 4.668

HOURS 10:00 & 14:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	21° 24'	21° 24' 00"	68° 36'	0.9310558	0.3648768	2.5515		1.0000000	Sp 2.551
1 %	0.01	0° 34' 20"	"	21 58 20	"	"	0.3741570	2.4883			Sps 2.488
				20 49 40			0.3555601		2.6186	0.9999501	Spn 2.619
2 %	0.02	1° 08' 40"	"	22 32 40	"	"	0.3834000	2.4284			Sps 2.428
				20 15 20			0.3462080		2.6893	0.9998005	Spn 2.688
3 %	0.03	1° 43' 10"	"	23 7 10	"	"	0.3926493	2.3712			Sps 2.370
				19 40 50			0.3367757		2.7646	0.9995497	Spn 2.763
4 %	0.04	2° 17' 30"	"	23 41 30	"	"	0.4018146	2.3171			Sps 2.315
				19 6 30			0.3273553		2.8442	0.9992002	Spn 2.842
5 %	0.05	2 51' 40"	"	24 16 40	"	"	0.4111608	2.2644			Sps 2.262
				18 32 20			0.3179[illegible]		2.9283	0.9987535	Spn 2.925

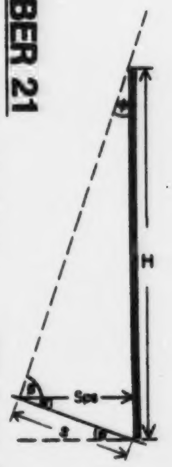
HOURS 11:00 & 13:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	25° 42'	25° 41' 00"	64° 28'	0.9010770	0.4336591	2.0778		1.0000000	Sp 2.077
1 %	0.01	0° 34' 20"	"	26 16 20	"	"	0.4426365	2.0357			Sps 2.035
				25 7 40			0.4246384		2.1220	0.9999501	Spn 2.121
2 %	0.02	1° 08' 40"	"	26 50 40	"	"	0.4515698	1.9954			Sps 1.995
				24 33 20			0.4155754		2.1682	0.9998005	Spn 2.167
3 %	0.03	1° 43' 10"	"	27 25 10	"	"	0.4605010	1.9567			Sps 1.955
				23 58 50			0.4064266		2.2170	0.9995397	Spn 2.126
4 %	0.04	2° 17' 30"	"	27 59 30	"	"	0.4693434	1.9199			Sps 1.918
				23 24 30			0.3972814		2.2681	0.9992002	Spn 2.266
5 %	0.05	2° 51' 40"	"	28 33 40	"	"	0.4780958	1.8847			Sps 1.882
				22 50 20			0.3881012		2.3215	0.9987535	Spn 2.318

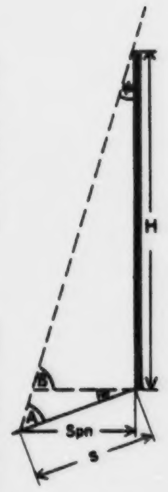
HOUR 12:00

SLOPE	Tang⁻¹	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	37° 12'	27° 12' 00"	62° 48'	0.8894164	0.4570979	1.9457		1.0000000	Sp 1.945
1 %	0.01	0° 34' 20"	"	27 46 20	"	"	0.4659577	1.9088			Sps 1.909
				26 37 40			0.4481925		1.9844	0.9999501	Spn 1.984
2 %	0.02	1° 08' 40"	"	28 20 40	"	"	0.4747711	1.8733			Sps 1.873
				26 3 20			0.4392424		2.0248	0.9998005	Spn 2.024
3 %	0.03	1° 43' 10"	"	28 55 10	"	"	0.4835795	1.8392			Sps 1.838
				25 28 50			0.4302408		2.0673	0.9995497	Spn 2.066
4 %	0.04	2° 17' 30"	"	29 29 30	"	"	0.4922970	1.8067			Sps 1.805
				24 54 30			0.4211677		2.1118	0.9992002	Spn 2.110
5 %	0.05	2° 51' 40"	"	30 3 40	"	"	0.5009234	1.7756			Sps 1.773
				24 20 20			0.4121329		2.1581	0.9987535	Spn 2.156

Date: DECEMBER 21



(Southern Slope)



(Northern Slope)

FORMULA

∠A = ∠B ± ∠θ

$S = \frac{H \cdot \sin\Phi}{\sin A}$

Sps or Spn = S·Cosθ

For Slopes h>5%

Sps or Spn $= \frac{100 \cdot S}{\sqrt{100^2 + h^2}}$

HOURS 05:00 & 19:00

SLOPE	Tang^{-1}	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"									So
1 %	0.01	0° 34' 20"									Sps Spn
2 %	0.02	1° 08' 40"				N					Sps Spn
3 %	0.03	1° 43' 10"				A					Sps Spn
4 %	0.04	2° 17' 30"									Sps Spn
5 %	0.05	2° 51' 40"									Sps Spn

HOURS 06:00 & 18:00

SLOPE	Tang^{-1}	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"									So
1 %	0.01	0° 34' 20"									Sps Spn
2 %	0.02	1° 08' 40"				N					Sps Spn
3 %	0.03	1° 43' 10"				A					Sps Spn
4 %	0.04	2° 17' 30"									Sps Spn
5 %	0.05	2° 51' 40"									Sps Spn

HOURS 07:00 & 17:00

SLOPE	Tang^{-1}	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"									So
1 %	0.01	0° 34' 20"									Sps Spn
2 %	0.02	1° 08' 40"				N					Sps Spn
3 %	0.03	1° 43' 10"				A					Sps Spn
4 %	0.04	2° 17' 30"									Sps Spn
5 %	0.05	2° 51' 40"									Sps Spn

HOURS 08:00 & 16:00

SLOPE	Tang^{-1}	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	3° 42'	3° 42' 00"	86° 18'	0.9979156	0.0645323	15.4644		1.0000000	So 15.464
1 %	0.01	0° 34' 20"	"	4 16 20 3 7 40	"	"	0.0744953 0.0545629	13.3962	18.2899	0.9999501	Sps 13.395 Spn 18.289
2 %	0.02	1° 08' 40"	"	4 50 40 2 33 20	"	"	0.0844508 0.0458807	11.8169	21.7510	0.9998005	Sps 11.815 Spn 21.747
3 %	0.03	1° 43' 10"	"	5 25 10 1 58 50	"	"	0.0944462 0.0345603	10.5663	28.8756	0.9995497	Sps 10.562 Spn 28.862
4 %	0.04	2° 17' 30"	"	5 59 30 1 24 30	"	"	0.1043838 0.0245776	9.8600	40.6026	0.9992002	Sps 9.552 Spn 40.570
5 %	0.05	2° 51' 40"	"	6 33 40 0 50 20	"	"	0.1142629 0.0146408	8.7335	68.1599	0.9987535	Sps 8.723 Spn 68.075

HOURS 09:00 & 15:00

SLOPE	Tang^{-1}	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	11° 42'	11° 42' 00"	78° 18'	0.979228	0.2027873	4.8288		1.0000000	So 4.828
1 %	0.01	0° 34' 20"	"	12 16 20 11 15 40	"	"	0.2125567 0.1952805	4.6069	5.0144	0.9999501	Sps 4.607 Spn 5.014
2 %	0.02	1° 08' 40"	"	12 50 40 10 33 20	"	"	0.2223049 0.1831888	4.4049	5.3454	0.9998005	Sps 4.404 Spn 5.344
3 %	0.03	1° 43' 10"	"	13 25 10 9 58 50	"	"	0.2320789 0.1733140	4.2194	5.6500	0.9995497	Sps 4.218 Spn 5.647
4 %	0.04	2° 17' 30"	"	13 59 30 9 24 30	"	"	0.2417808 0.1634695	4.0500	5.9903	0.9992002	Sps 4.047 Spn 5.986
5 %	0.05	2 51' 40"	"	14 33 40 8 50 20	"	"	0.2515125 0.1536566	3.8949	6.3728	0.9987535	Sps 3.890 Spn 6.365

HOURS 10:00 & 14:00

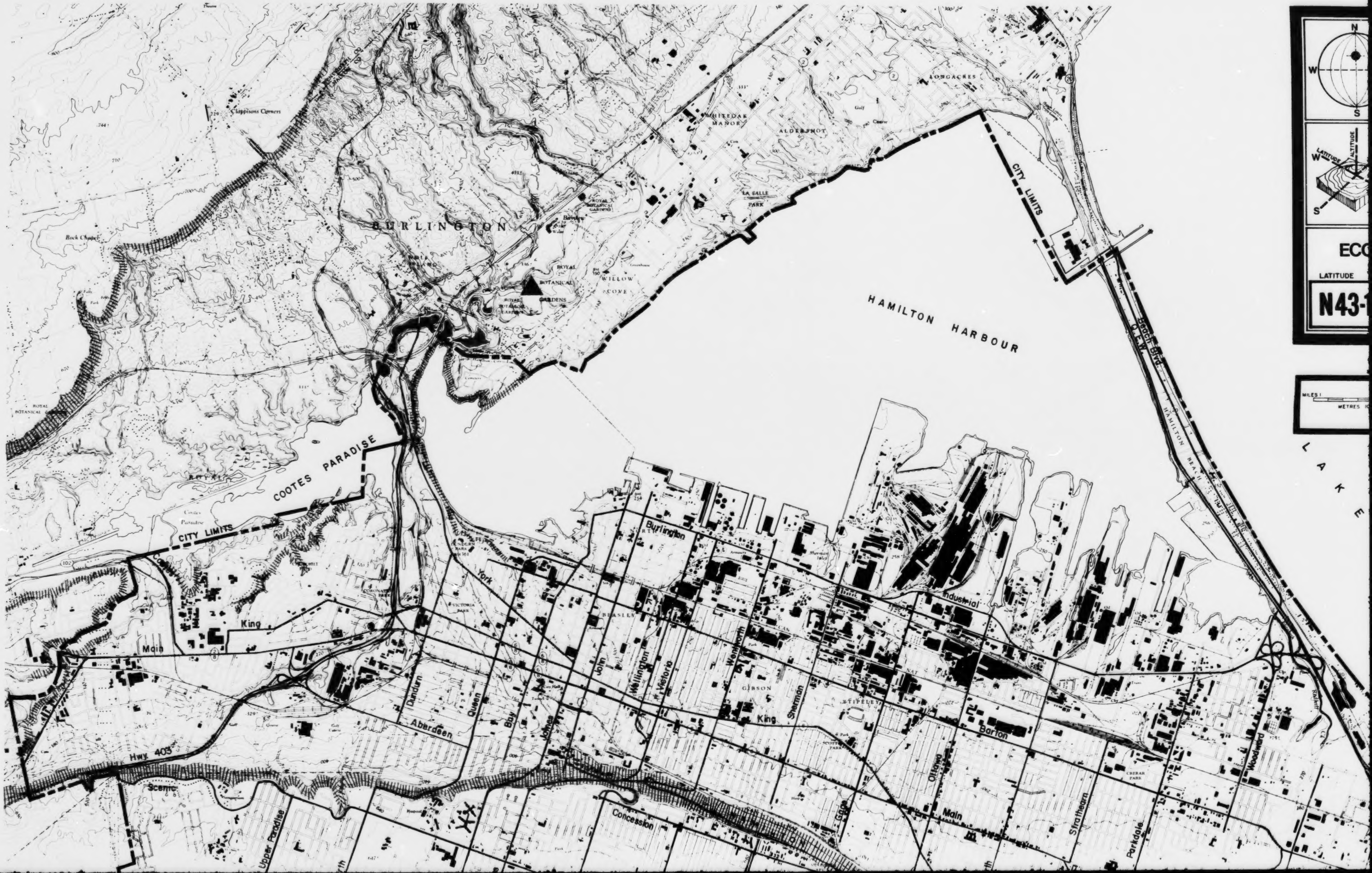
SLOPE	Tang^{-1}	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	18° 00'	18° 00' 00"	72° 00'	0.9512361	0.3090170	3.0783		1.0000000	So 3.077
1 %	0.01	0° 34' 20"	"	18 34 20 17 25 40	"	"	0.3184998 0.2995034	2.9866	3.1760	0.9999501	Sps 2.986 Spn 3.176
2 %	0.02	1° 08' 40"	"	19 8 40 16 51 20	"	"	0.3279508 0.2899599	2.9005	3.2806	0.9998005	Sps 2.900 Spn 3.280
3 %	0.03	1° 43' 10"	"	19 43 10 16 16 50	"	"	0.3374147 0.2803410	2.8192	3.3931	0.9995497	Sps 2.818 Spn 3.392
4 %	0.04	2° 17' 30"	"	20 17 30 15 42 30	"	"	0.3467992 0.2707405	2.7429	3.5135	0.9992002	Sps 2.741 Spn 3.511
5 %	0.05	2 51' 40"	"	20 51 40 15 8 20	"	"	0.3561038 0.2611598	2.6710	3.6423	0.9987535	Sps 2.669 Spn 3.638

HOURS 11:00 & 13:00

SLOPE	Tang^{-1}	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	22° 6'	22° 6' 00"	67° 54'	0.9265286	0.3762243	2.4627		1.0000000	So 2.462
1 %	0.01	0° 34' 20"	"	22 40 20 21 31 40	"	"	0.3854587 0.3669522	2.4037	2.5249	0.999950	Sps 2.403 Spn 2.524
2 %	0.02	1° 08' 40"	"	23 14 40 20 57 20	"	"	0.3946547 0.3576436	2.3477	2.5906	0.9998005	Sps 2.347 Spn 2.590
3 %	0.03	1° 43' 10"	"	23 49 10 20 22 50	"	"	0.4038558 0.3482594	2.2942	2.6604	0.9995497	Sps 2.293 Spn 2.659
4 %	0.04	2° 17' 30"	"	24 23 30 19 48 30	"	"	0.4129719 0.3388747	2.2435	2.7341	0.9992002	Sps 2.242 Spn 2.732
5 %	0.05	2° 51' 40"	"	24 57 40 19 14 20	"	"	0.4220030 0.3295075	2.1955	2.8118	0.9987535	Sps 2.193 Spn 2.808

HOUR 12:00

SLOPE	Tang^{-1}	∠θ	∠B	∠A=∠B±∠θ	∠Φ	SinΦ	SinA	s. $S=\frac{H\cdot\sin\Phi}{\sin A}$	n.	Cosθ	Sps or Spn
0 %	0.00	0° 00' 00"	23° 36	23° 36' 00"	66° 24'	0.9163627	0.4003490	2.2885		1.0000000	So 2.288
1 %	0.01	0° 34' 20"	"	24 10 20 23 1 40	"	"	0.4094808 0.3911774	2.2379	2.3926	0.9999501	Sps 2.238 Spn 2.392
2 %	0.02	1° 08' 40"	"	24 44 40 22 27 20	"	"	0.4185717 0.3819667	2.1893	2.3991	0.9998005	Sps 2.189 Spn 2.398
3 %	0.03	1° 43' 10"	"	25 19 10 21 52 50	"	"	0.4276647 0.3726729	2.1427	2.4589	0.9995497	Sps 2.142 Spn 2.458
4 %	0.04	2° 17' 30"	"	25 53 30 21 18 30	"	"	0.4366709 0.3633867	2.0985	2.5217	0.9992002	Sps 2.097 Spn 2.520
5 %	0.05	2° 51' 40"	"	26 27 40 20 44 20	"	"	0.4455903 0.3541097	2.0565	2.5878	0.9987535	Sps 2.054 Spn 2.584



Clappisons Corners
Rock Chapel
BURLINGTON
ROYAL BOTANICAL GARDENS
WILLOW COVE
WHITEOAK MANOR
ALDERSHOT
LONGACRES
LA SALLE PARK
HAMILTON HARBOUR
CITY LIMITS
COOTES PARADISE
Cootes Paradise
Beach Blvd
Q.E.W.
HAMILTON BEACH
LAKE
King
Main
York
Burlington
Industrial
Barton
Dundurn
Queen
Bay
James
John
Wellington
Victoria
Wentworth
Sherman
Ottawa
Gage
Strathearn
Parkdale
Woodward
Aberdeen
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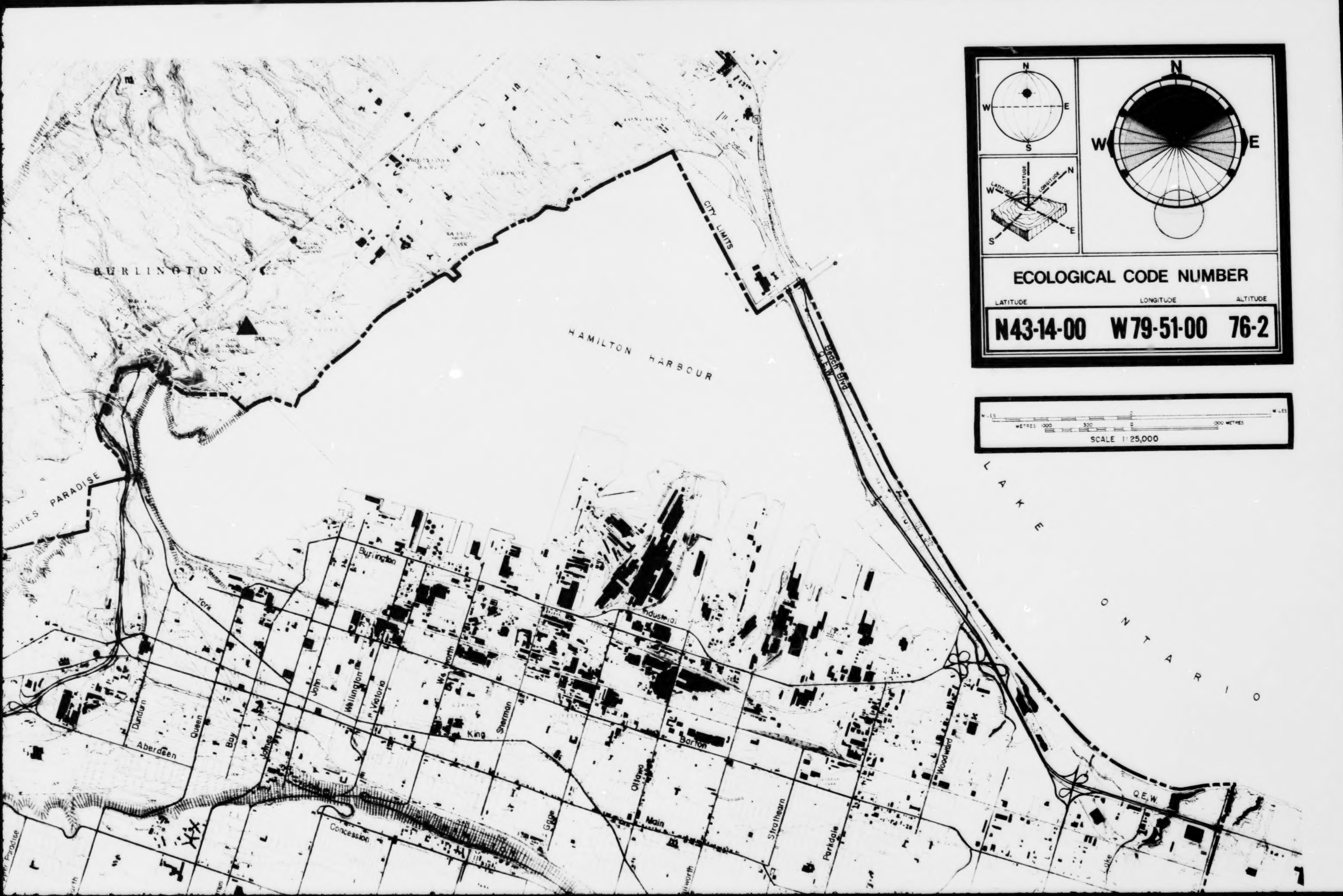
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CITY LIMITS
LAKE ONTARIO
COOTES PARADISE
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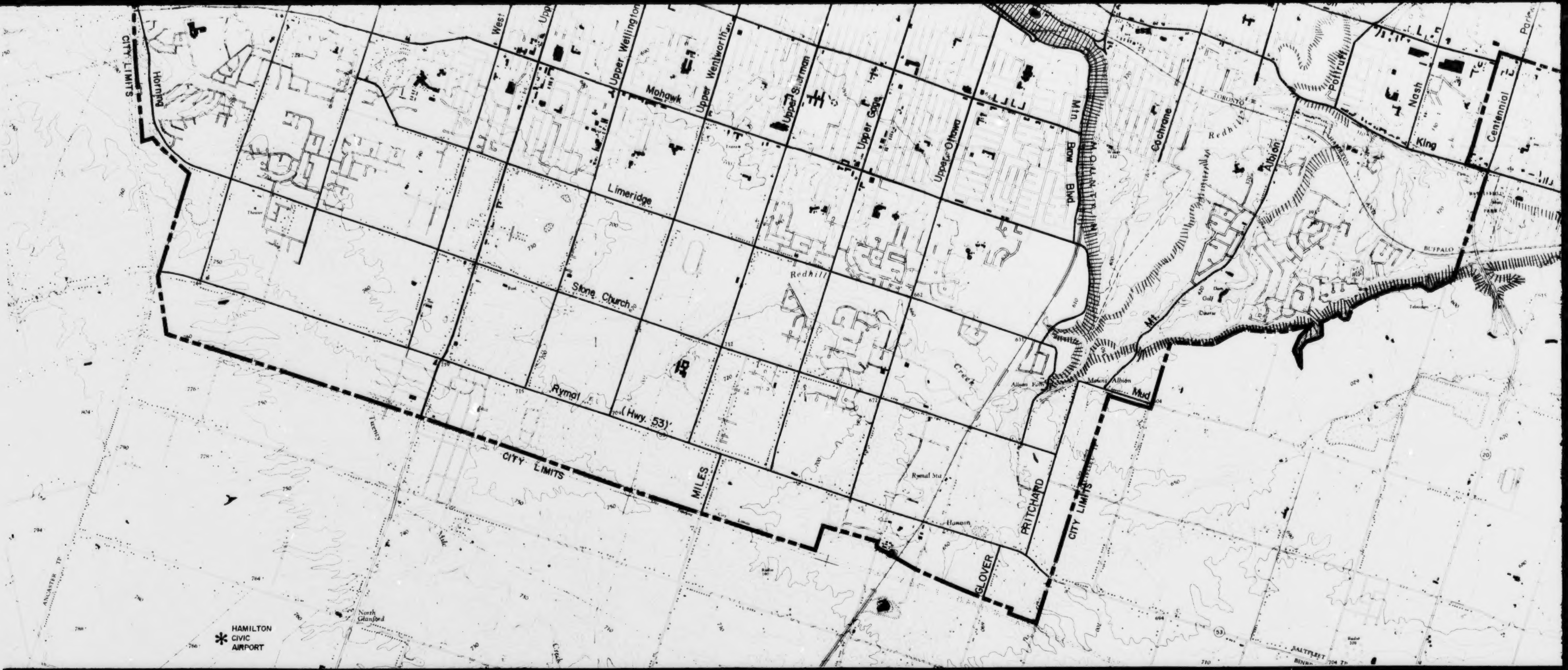
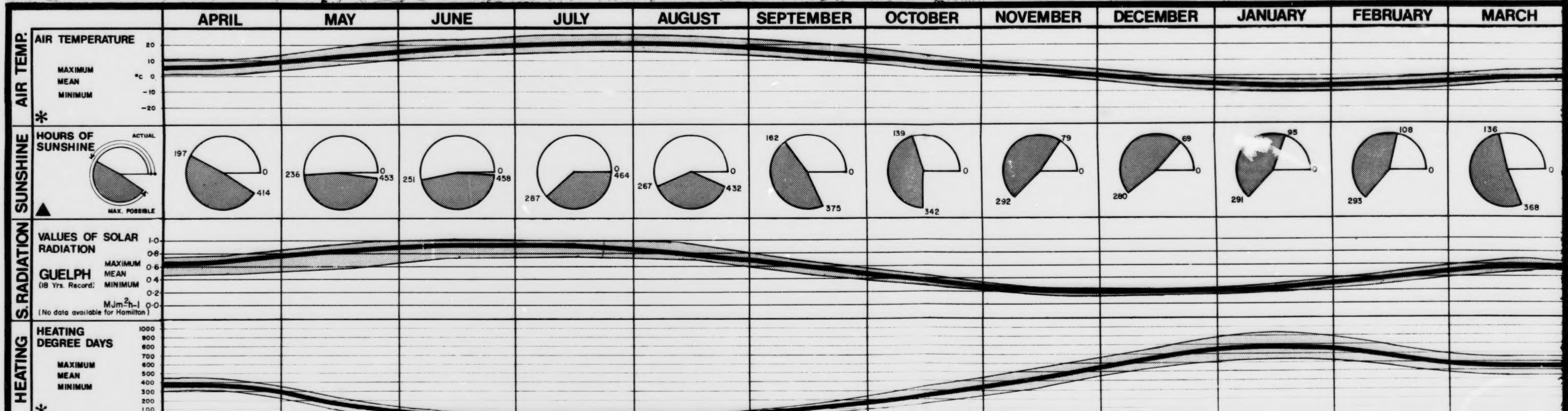
Concession
Strathearn
Parkdale
Woodward
Q.E.W.


CITY LIMITS
Horning
West
Upper Wellington
Upper Wentworth
Mohawk
Upper Sherman
Upper Gage
Upper Ottawa
Mtn. Brow Blvd.
Cochrane
Redhill
Albion
Pottruff
Nash
King
Centennial
TORONTO
BUFFALO
Limeridge
Stone Church
Redhill
Creek
Rymal
(Hwy. 53)
CITY LIMITS
MILES
Rymal Sta.
Hannon
PRITCHARD
GLOVER
CITY LIMITS
Mt. Albion
Albion Falls
Mud
HAMILTON CIVIC AIRPORT
North Glanford
BINBROOK


APRIL
MAY
JUNE
JULY
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SEPTEMBER
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MARCH
AIR TEMP.
AIR TEMPERATURE
MAXIMUM
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SUNSHINE
HOURS OF SUNSHINE
ACTUAL
MAX. POSSIBLE
▲
197 0 414
236 0 453
251 0 458
287 0 464
267 0 432
162 0 375
139 0 342
79 0 292
69 0 280
95 0 291
108 0 293
136 0 368
S. RADIATION
VALUES OF SOLAR RADIATION
GUELPH
(18 Yrs. Record)
MAXIMUM
MEAN
MINIMUM
MJm⁻²h⁻¹
1·0
0·8
0·6
0·4
0·2
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(No data available for Hamilton)
HEATING
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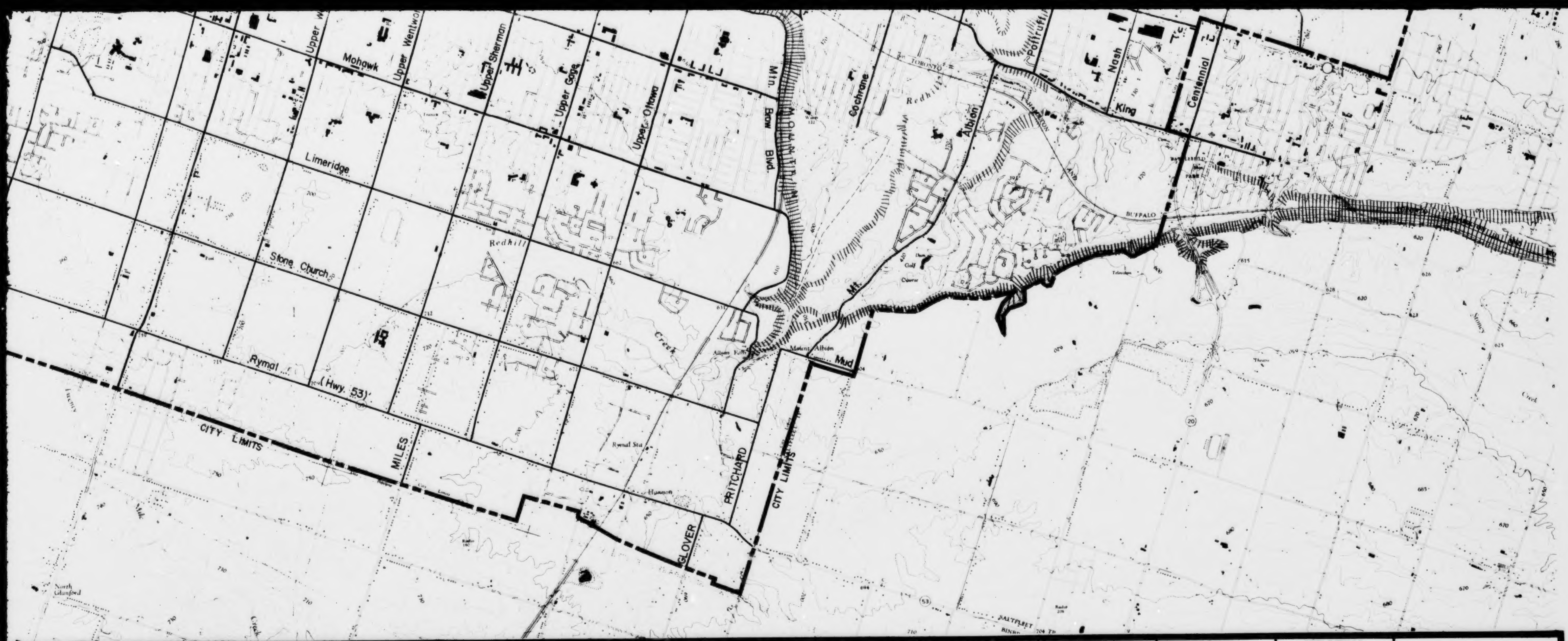
Upper Wentworth
Mohawk
Upper Sherman
Upper Gage
Upper Ottawa
Mtn. Brow Blvd.
Limeridge
Redhill
Stone Church
Rymal
(Hwy. 53)
CITY LIMITS
MILES
Creek
Rymal Sta.
Hannon
PRITCHARD
GLOVER
CITY LIMITS
Albion Falls
Mount Albion
Mud
Cochrane
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TORONTO
Redhill
Nash
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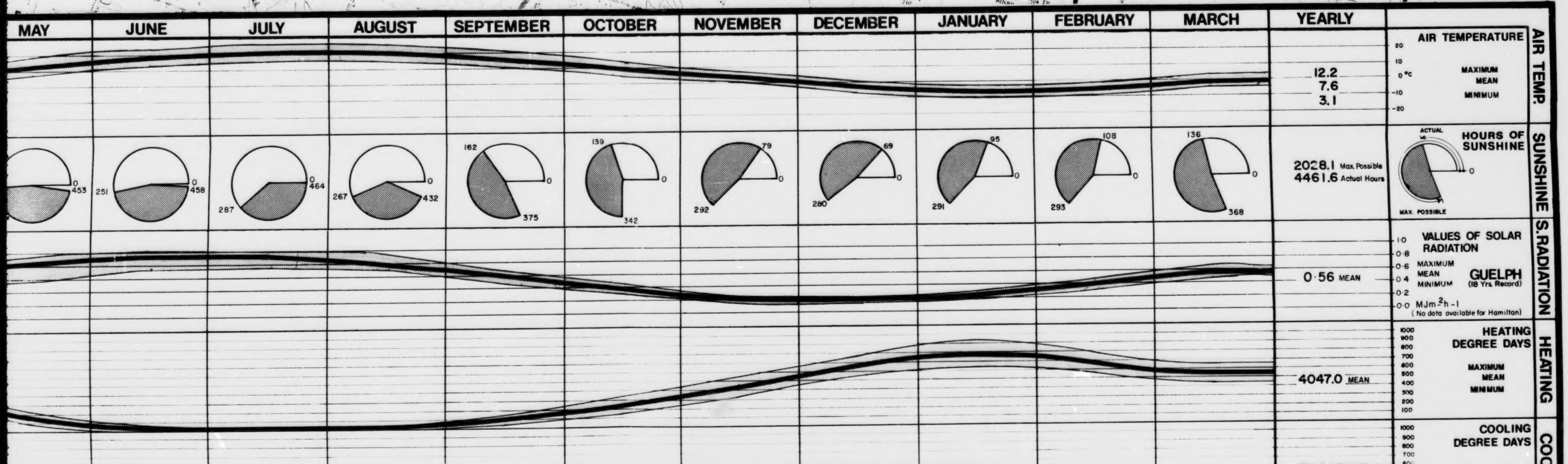
Centennial
BUFFALO
North Glanford
SALTFLEET


MAY
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SEPTEMBER
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NOVEMBER
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12.2
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AIR TEMPERATURE
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MAXIMUM
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AIR TEMP.
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287
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375
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69
280
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95
291
0
108
293
0
136
368
2028.1 Max. Possible
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0·8
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VALUES OF SOLAR RADIATION
MAXIMUM
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(18 Yrs. Record)
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(No data available for Hamilton)
S.RADIATION
4047.0 MEAN
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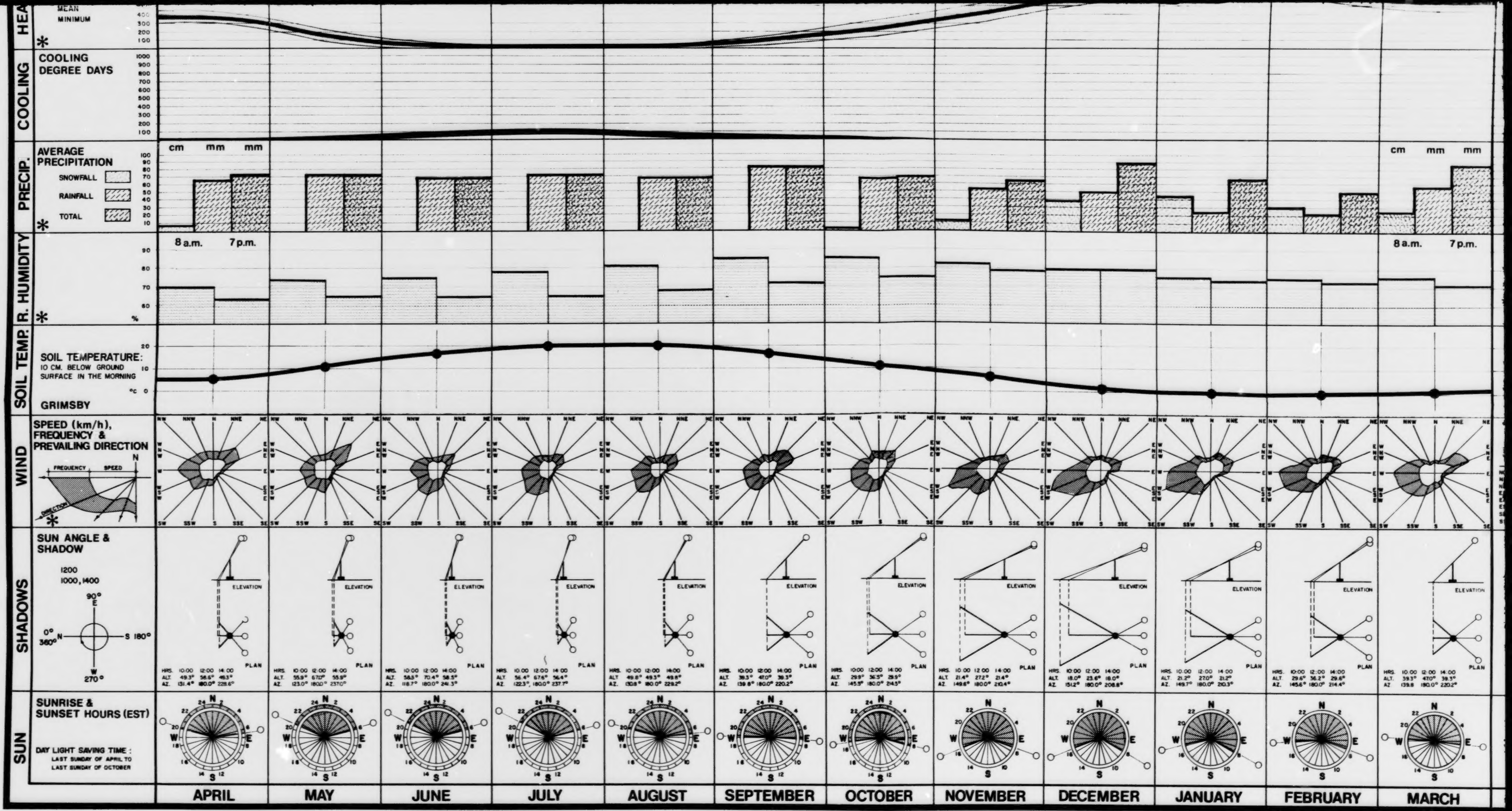
COOLING DEGREE DAYS
COO



WEATHER RECORDING STATIONS

* HAMILTON CIVIC AIRPORT

▲ ROYAL BOTANICAL GARDENS

ECOCHART OF H

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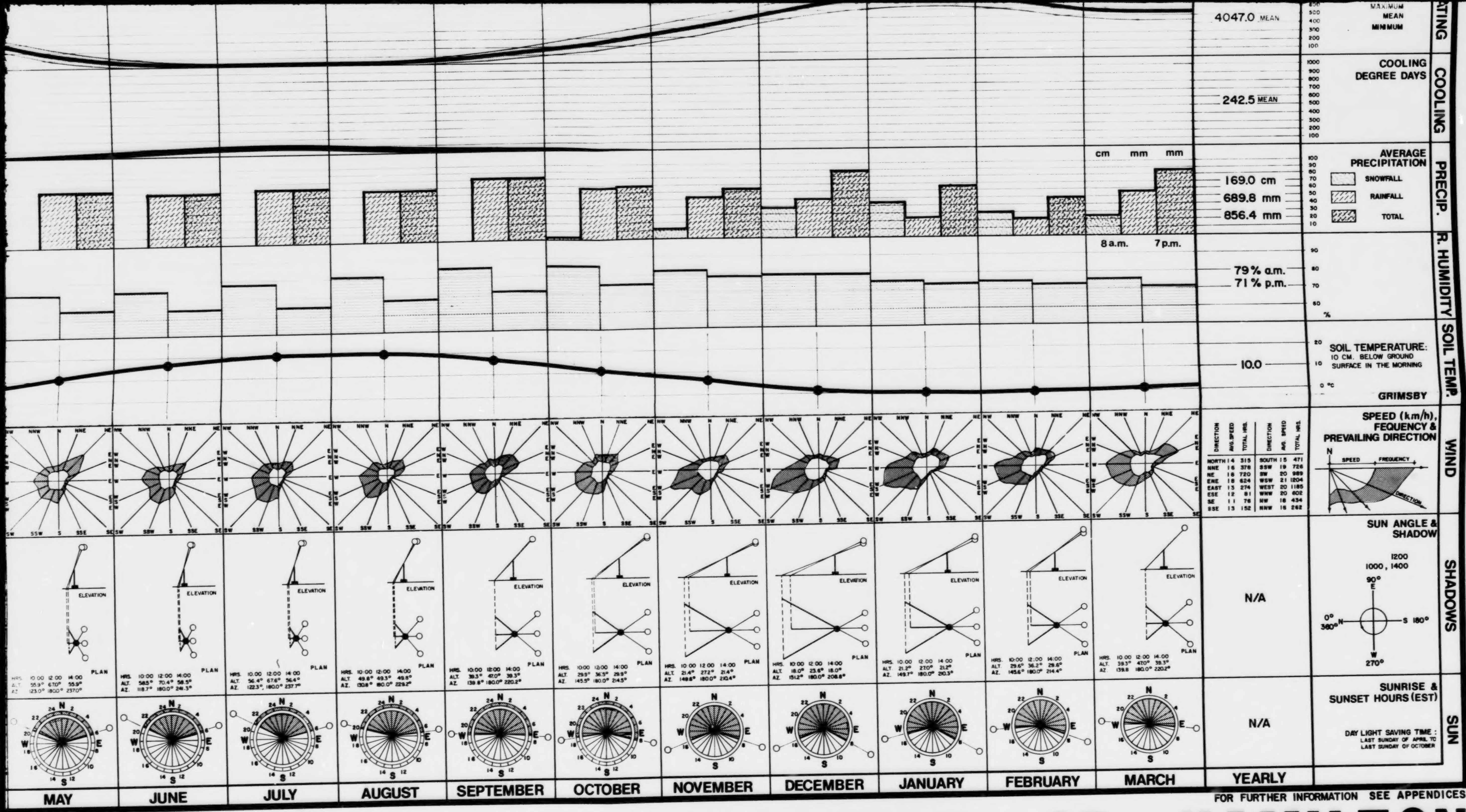
URBAN DOCUMENTATION CENTRE
RESEARCH UNIT FOR URBAN STUDIES
McMASTER UNIVERSITY
HAMILTON, ONTARIO



DIRECTION	AVG. SPEED	TOTAL HRS.	DIRECTION	AVG. SPEED	TOTAL HRS.
NORTH	14	315	SOUTH	15	471
NNE	16	378	SSW	19	726
NE	16	720	SW	20	989
ENE	18	624	WSW	21	1204
EAST	13	274	WEST	20	1185
ESE	12	81	WNW	20	602
SE	11	76	NW	18	434
SSE	13	152	NNW	16	262

FOR FURTHER INFORMATION SEE APPENDICES

ECOCHART OF HAMILTON

Planning and Development Department
Hamilton-Wentworth Region

September, 1982

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McMASTER UNIVERSITY
HAMILTON, ONTARIO

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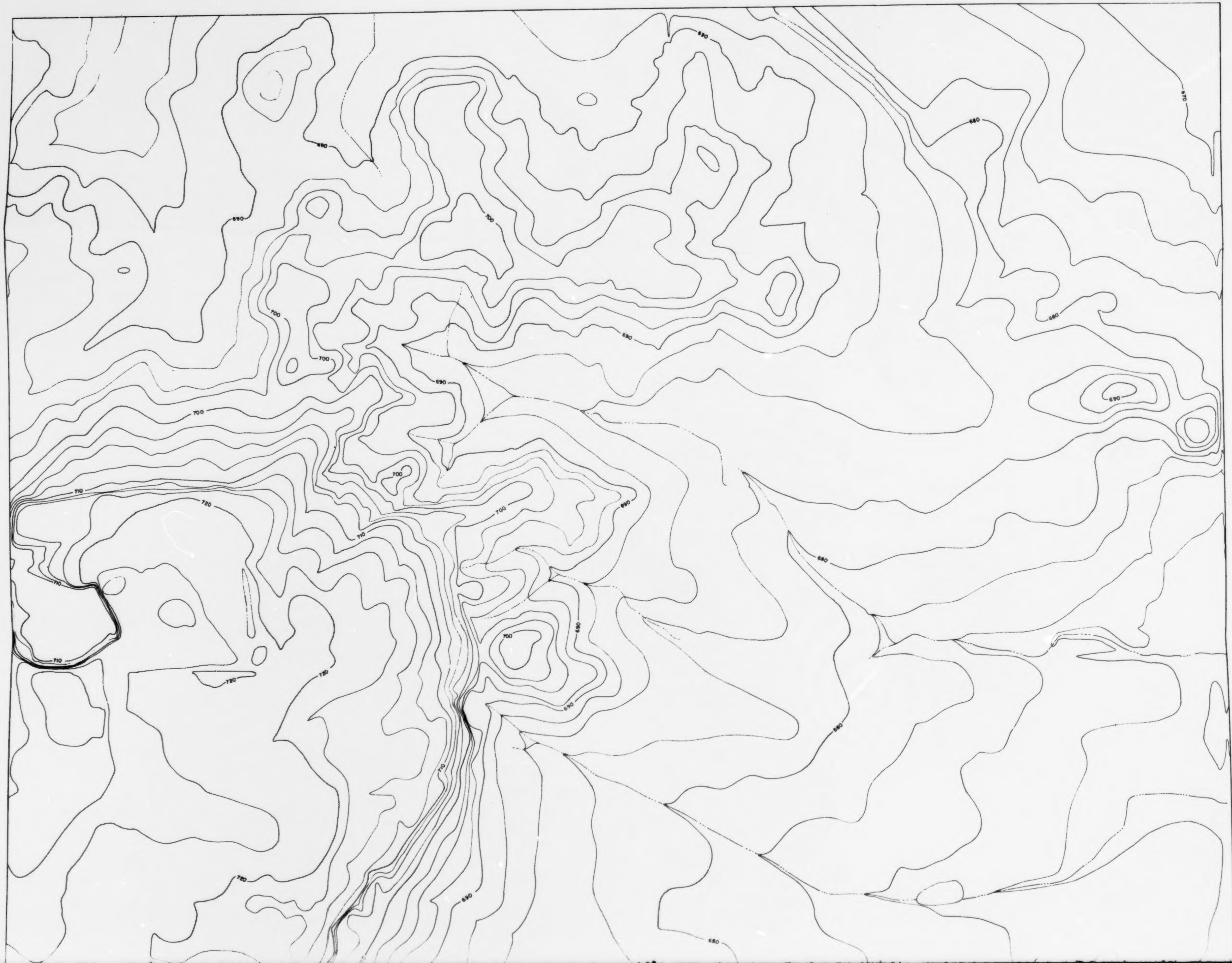
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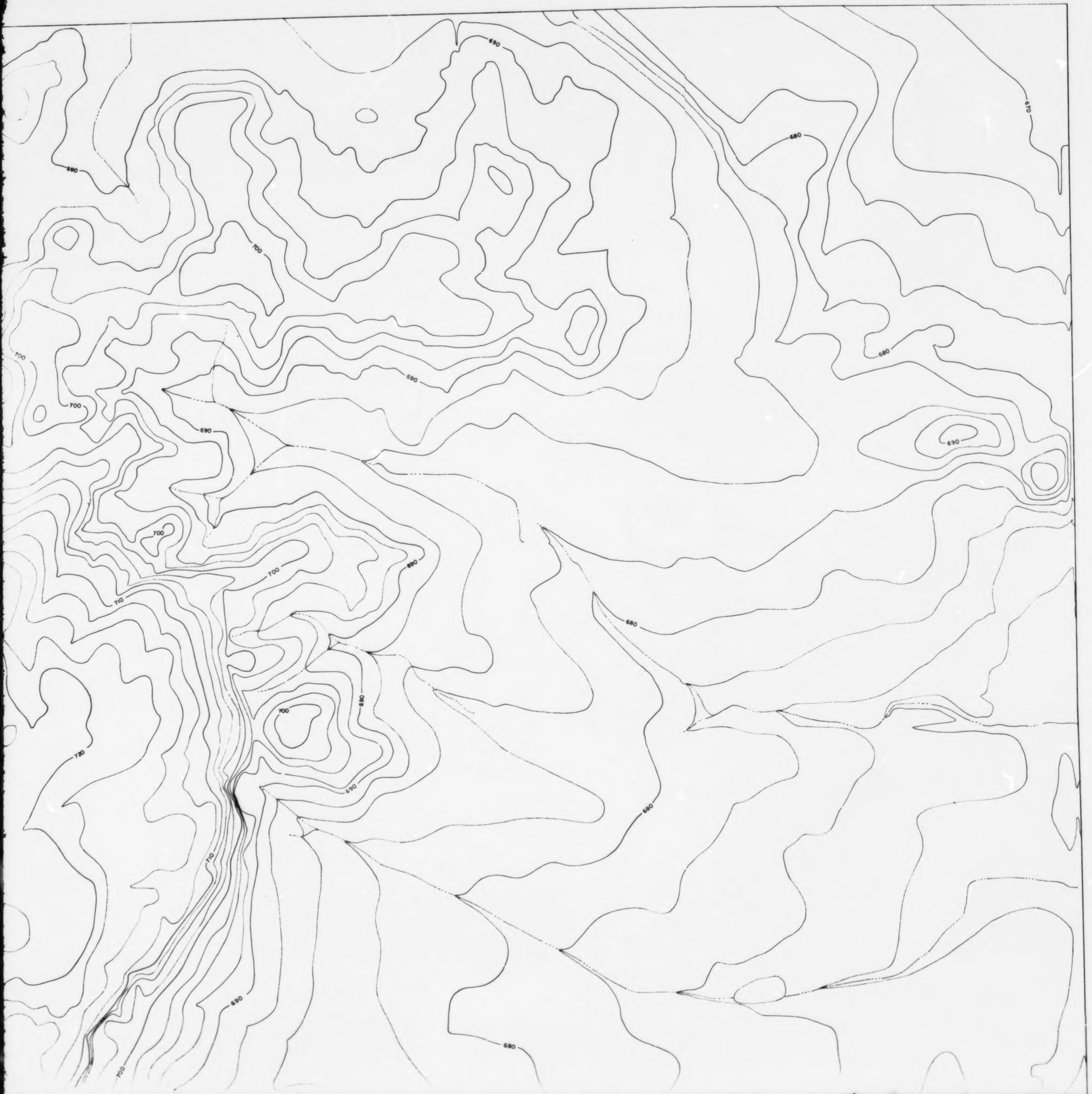
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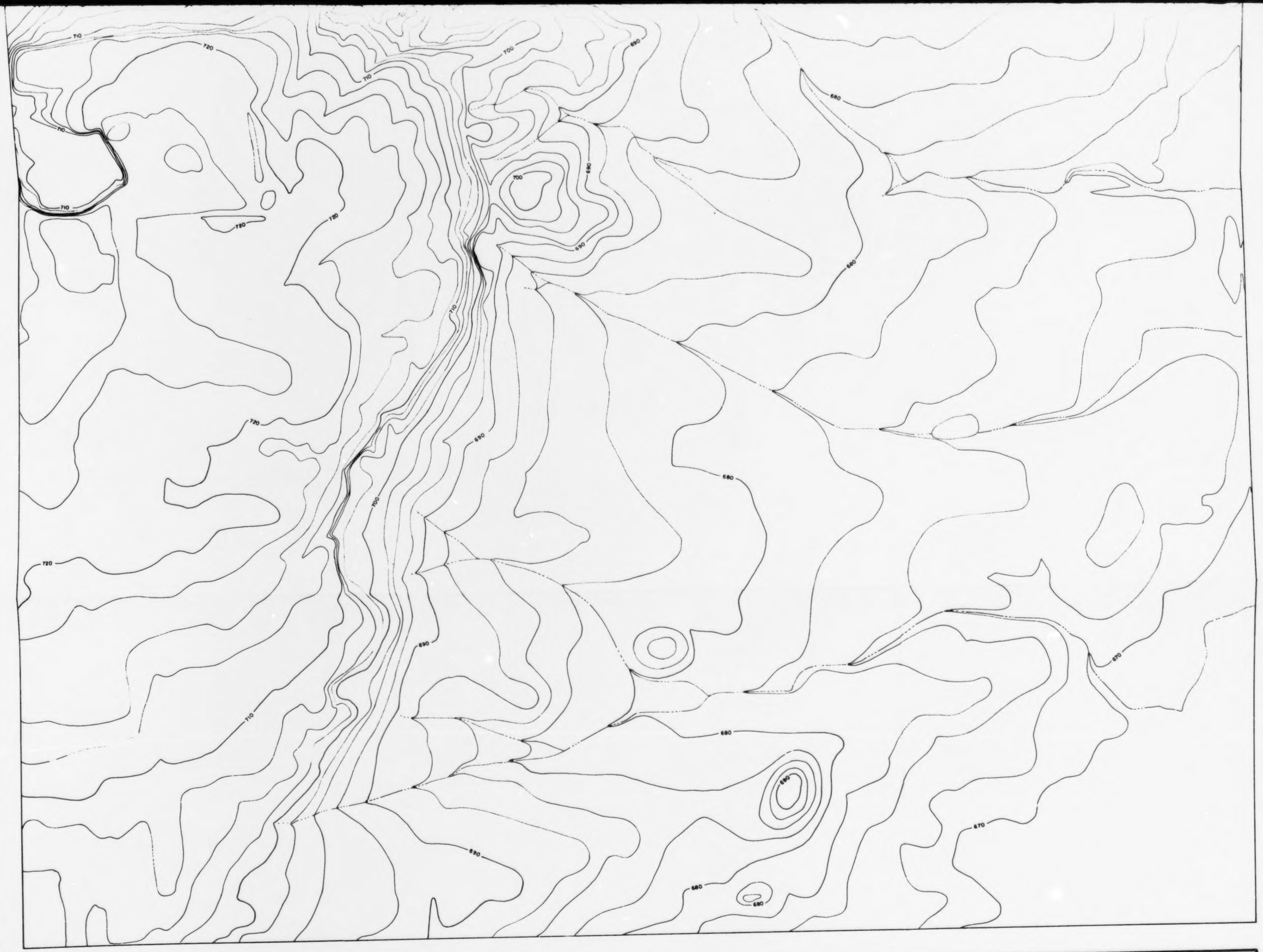
HAMILTON, ONTARIO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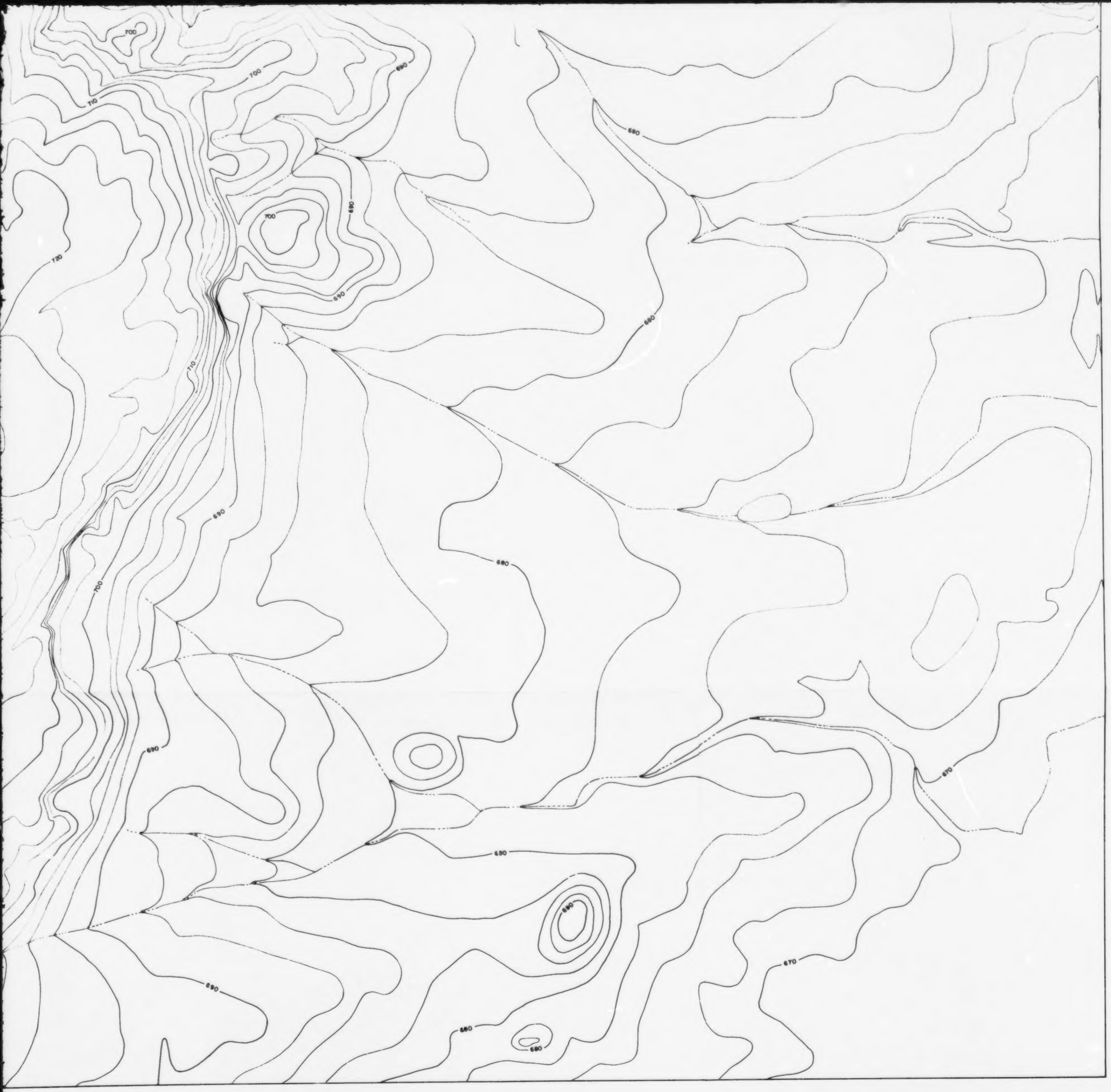
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CONVENTIONAL CONTOUR MAP

DESIGN CRITERIA FOR ENERGY EFFICIENT NEIGHBOURHOOD PLANNING

PREPARED FOR THE CITY OF HAMILTON
BY THE
PLANNING AND DEVELOPMENT DEPARTMENT
OF THE
REGIONAL MUNICIPALITY OF HAMILTON - WENTWORTH

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September 1982

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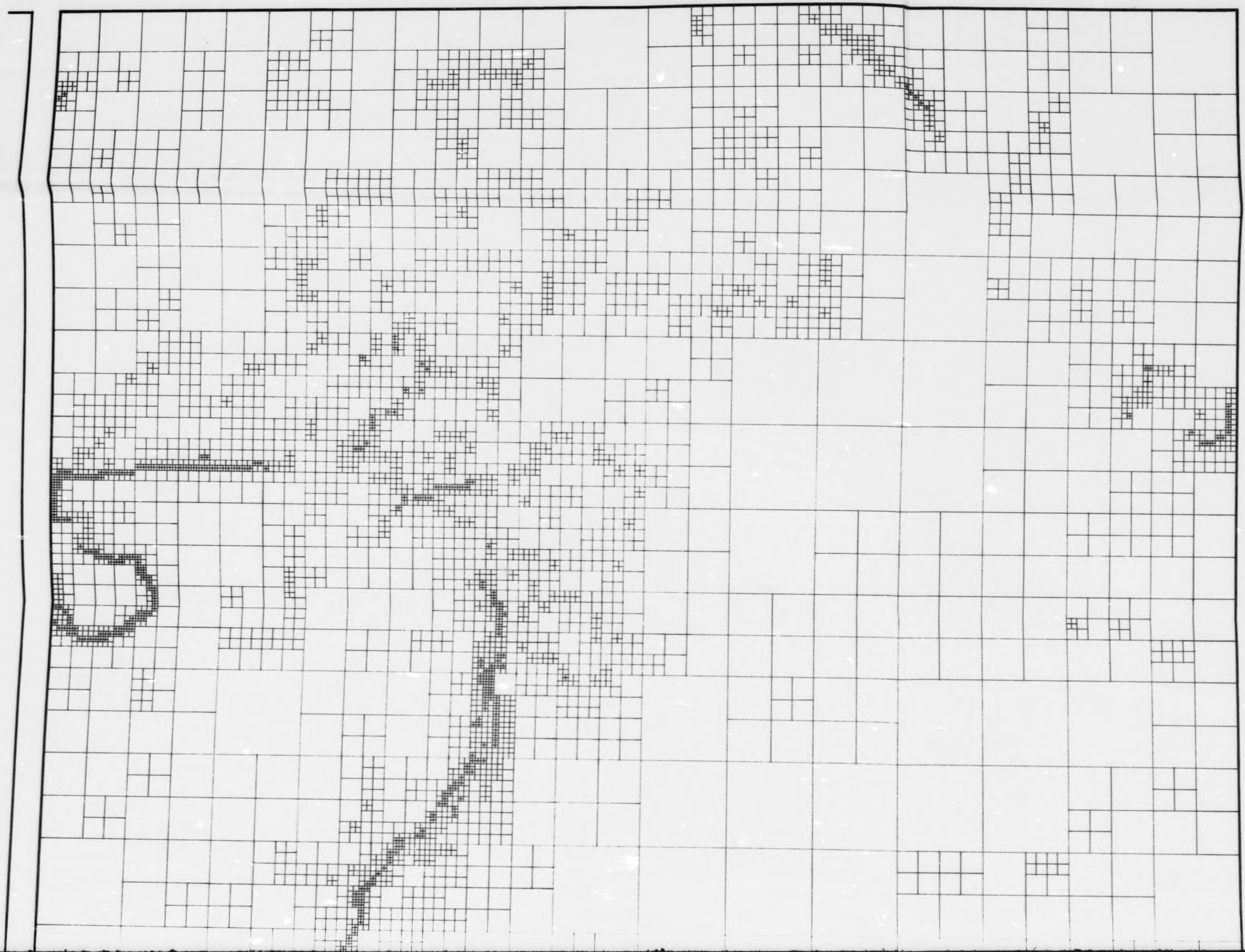

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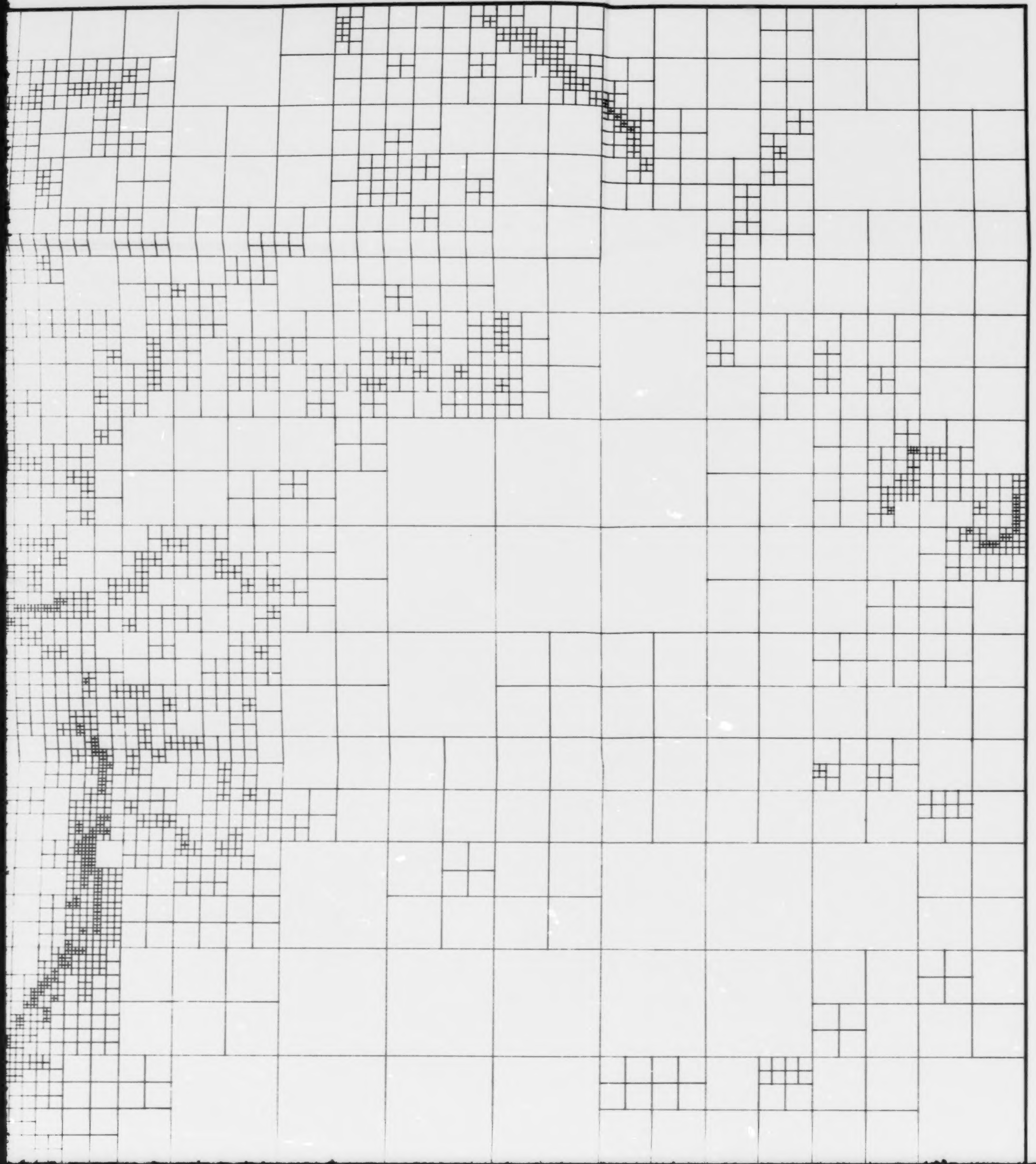
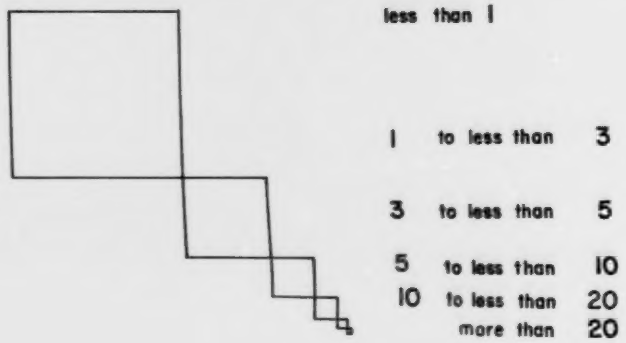
McMASTER UNIVERSITY
HAMILTON, ONTARIO



Degree of Slope %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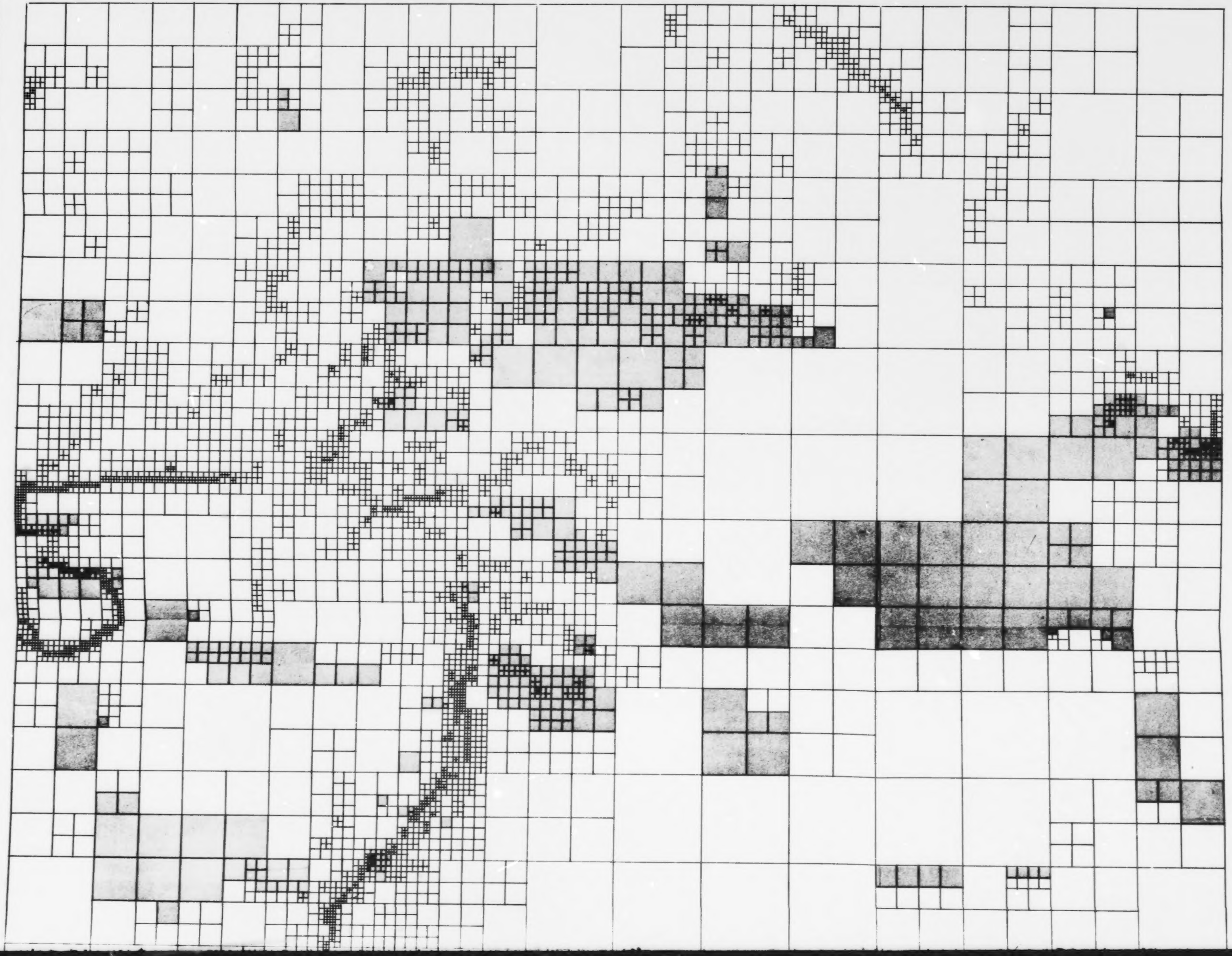
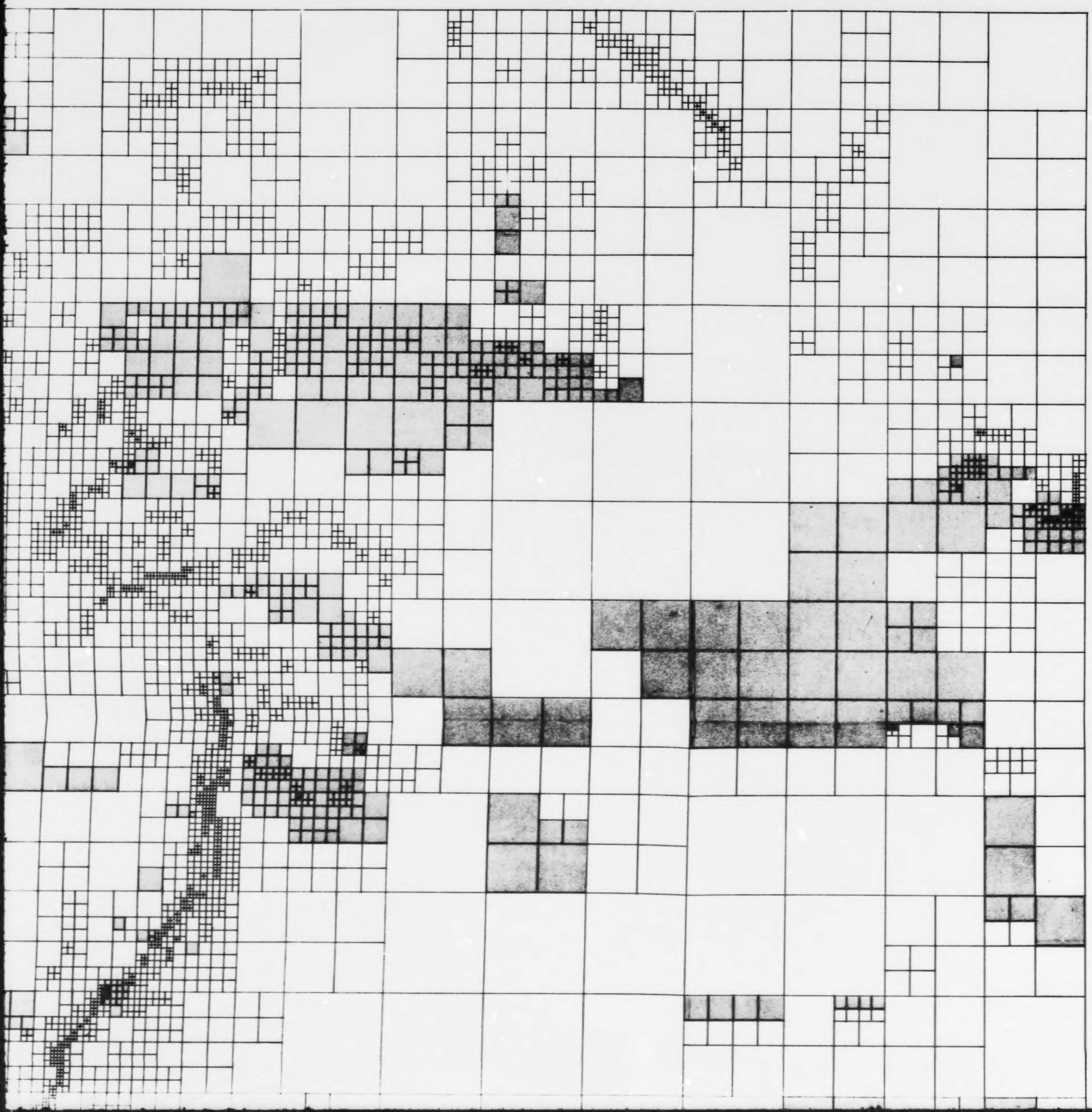
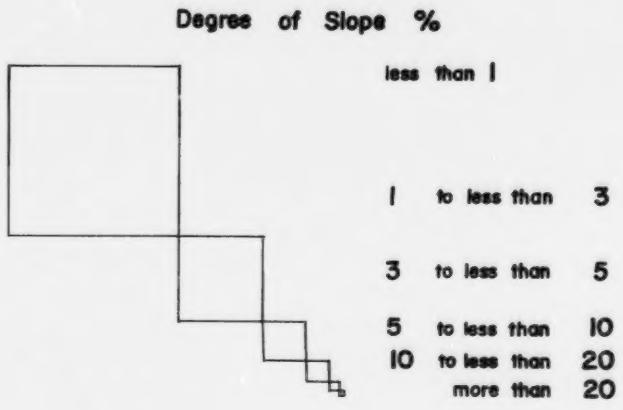


TOTAL AREA OF PLAN	
ACRES	HECT.
206·5	83·7




Degree of Slope %
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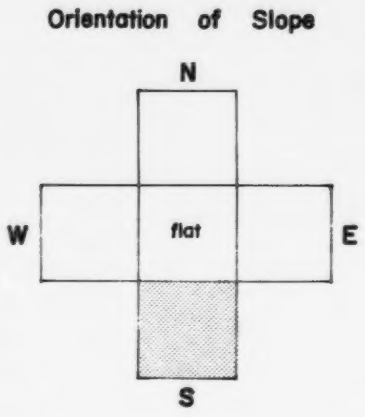
Orientation of Slope
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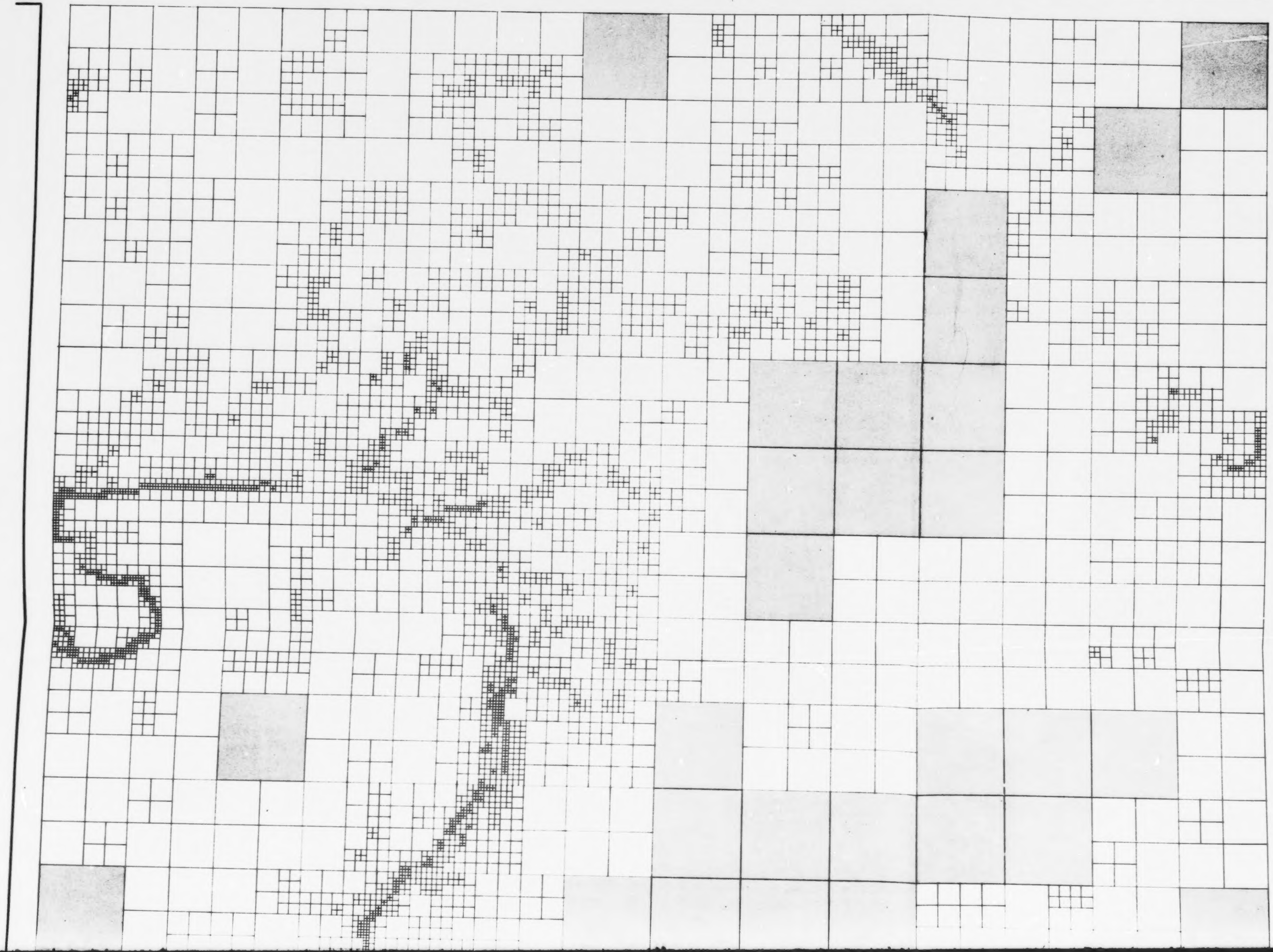
TOTAL AREA OF PLAN		SHADED AREA		PERCENTAGE
ACRES	HECT.	ACRES	HECT.	
206·5	83·7	41·3	16·7	20



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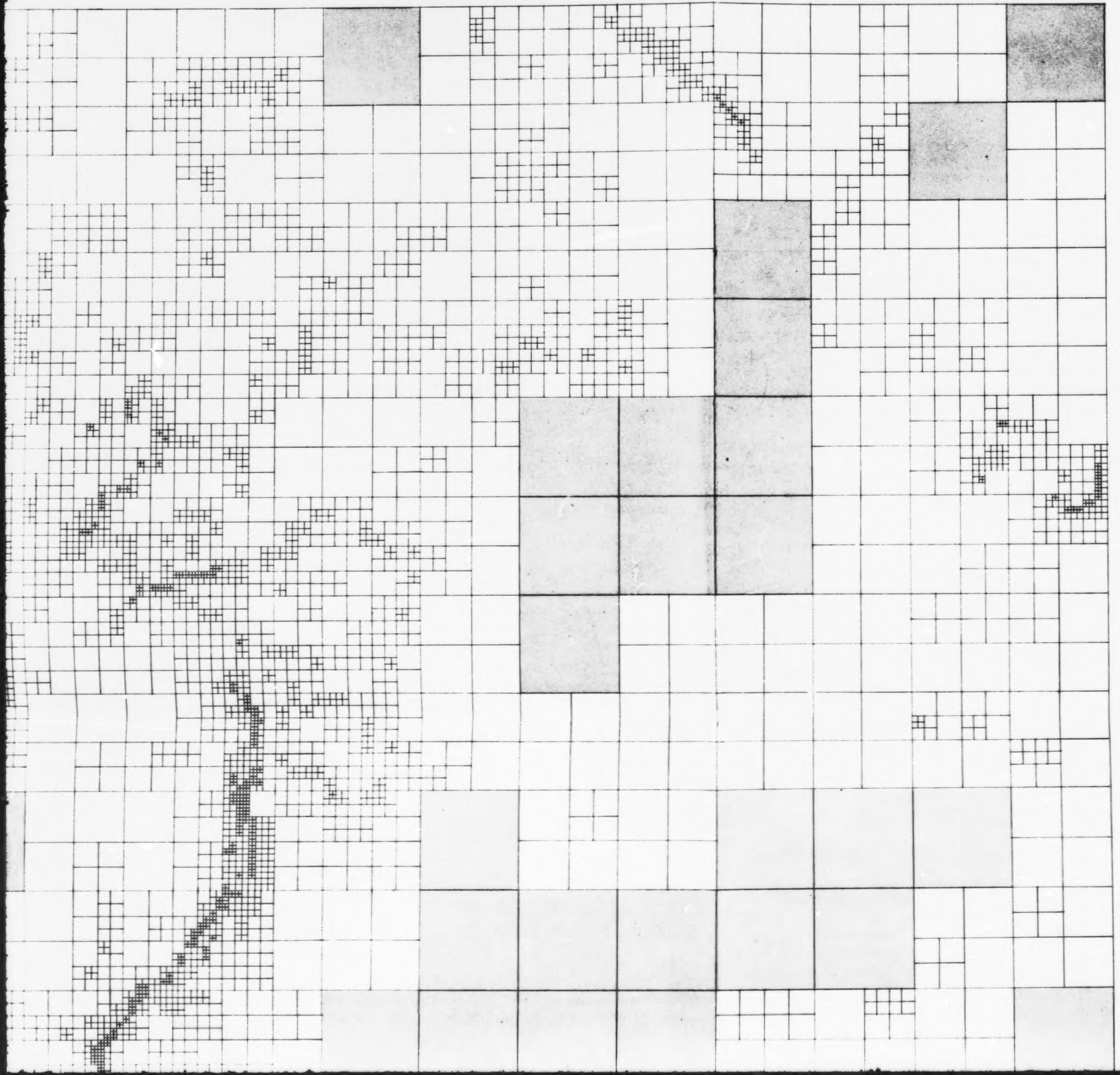
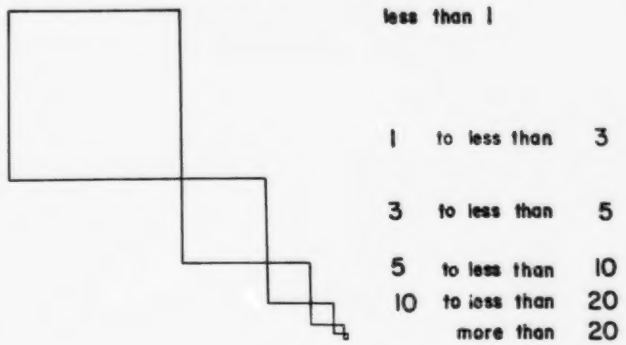
TOTAL ARE OF PLAN	
ACRES	HE(
206·5	83



Degree of Slope %


less than 1
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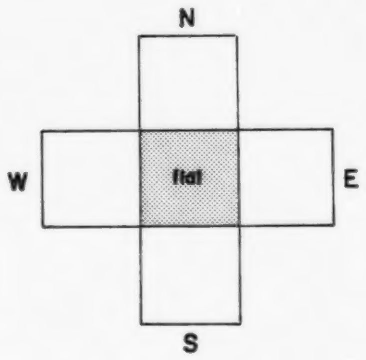
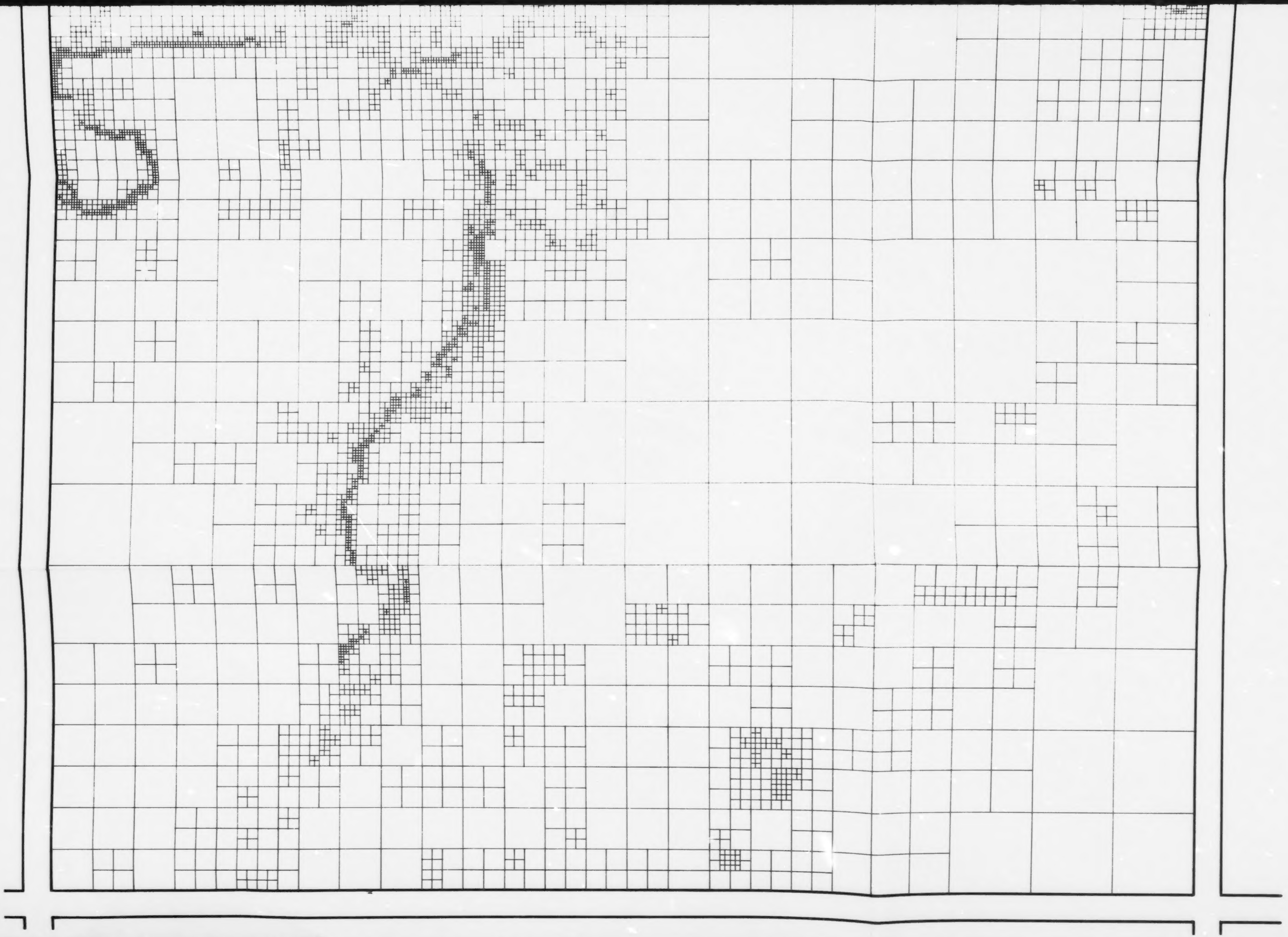
3 to less than 5
5 to less than 10
10 to less than 20
more than 20

Orientation of Slope



TOTAL AREA OF PLAN		SHADED AREA		PERCENTAGE
ACRES	HECT.	ACRES	HECT.	
206·5	83·7	39·5	16	19·1



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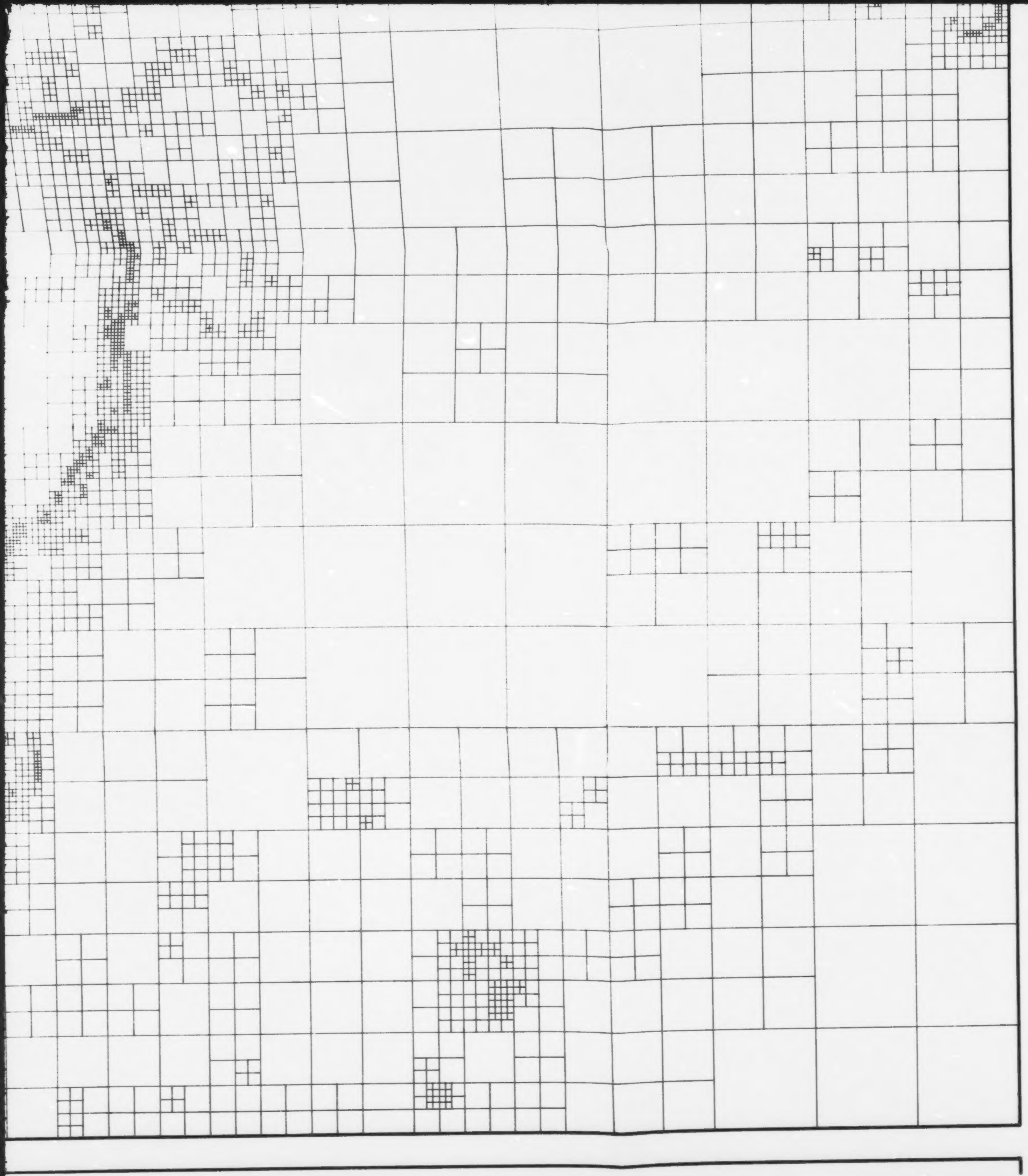

SLOPE GRADIENT DESCRIPTION

DESIGN CRITERIA FOR ENERGY EFFICIENT NEIGHBOURHOOD PLANNING

PREPARED FOR THE CITY OF HAMILTON

PLANNING AND DEVELOPMENT DEPARTMENT

REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

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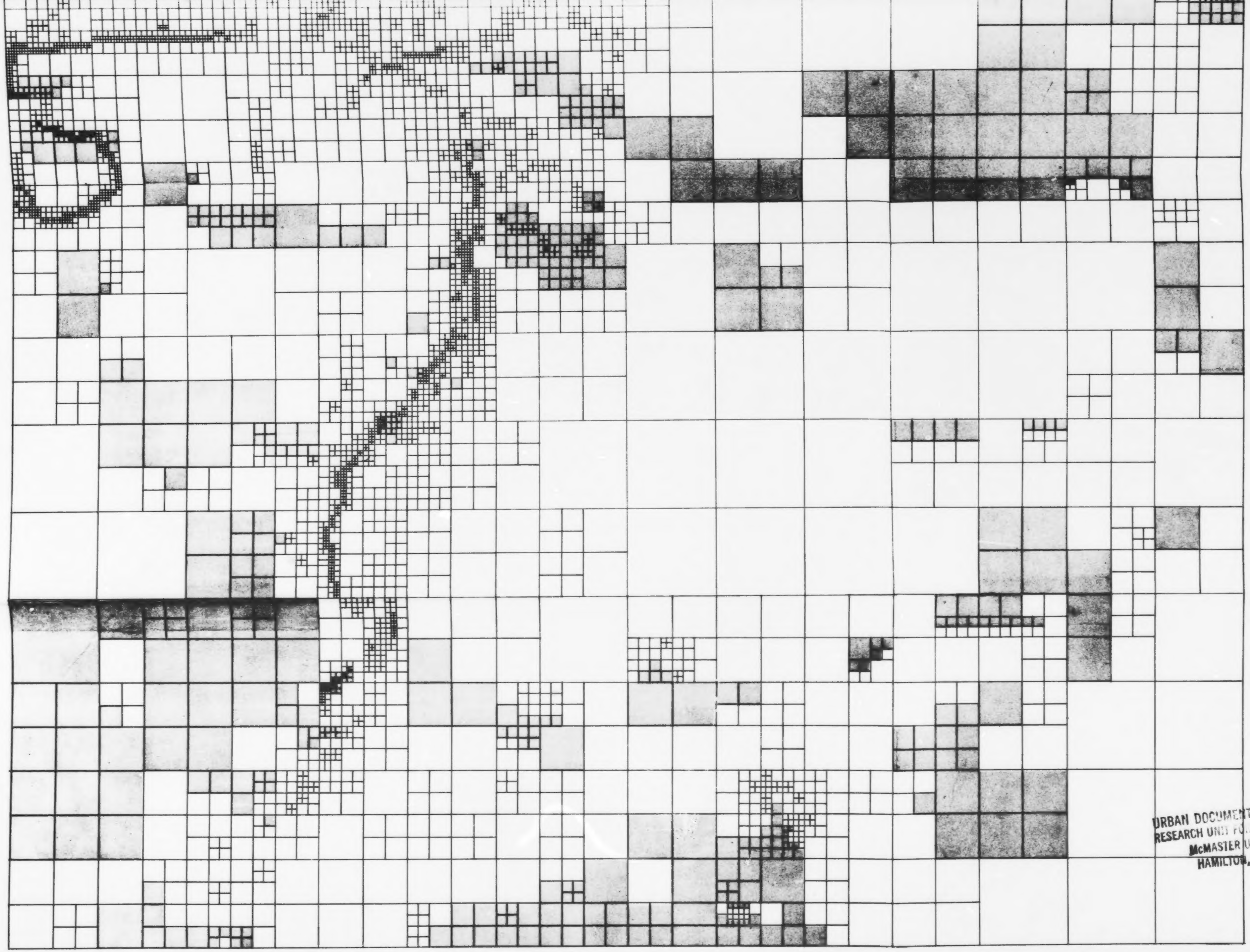

TOTAL AREA OF PLAN	
ACRES	HECT.
206·5	83·7

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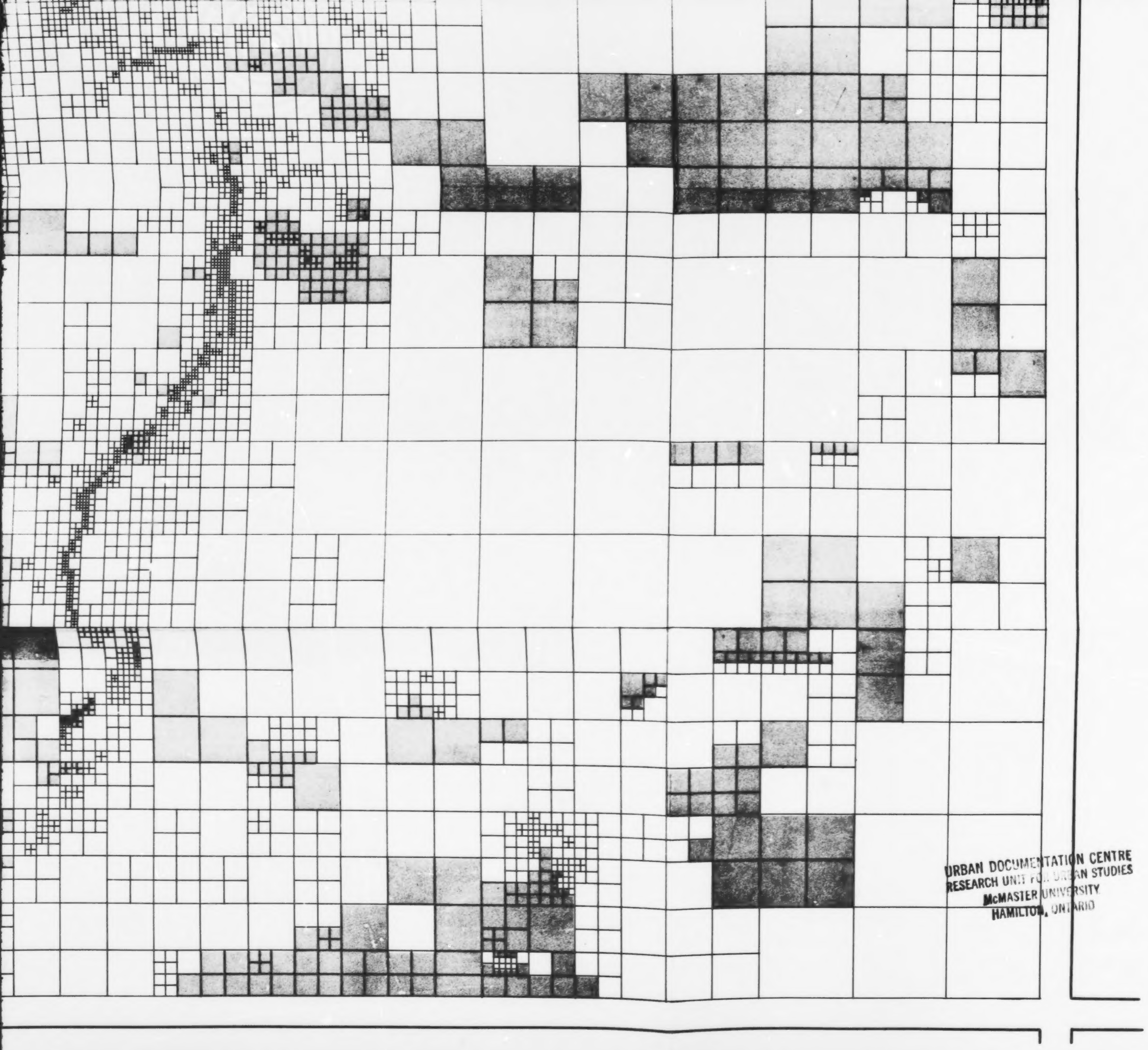
HAMILTON, ONTARIO



TOTAL AREA OF PLAN		SHADED AREA		PERCENTAGE
ACRES	HECT.	ACRES	HECT.	
206·5	83·7	41·3	16·7	20

SLOPE DESCRIPTIVE MATRIX

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PREPARED FOR THE CITY OF HAMILTON
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0 50m 100m

September 1982

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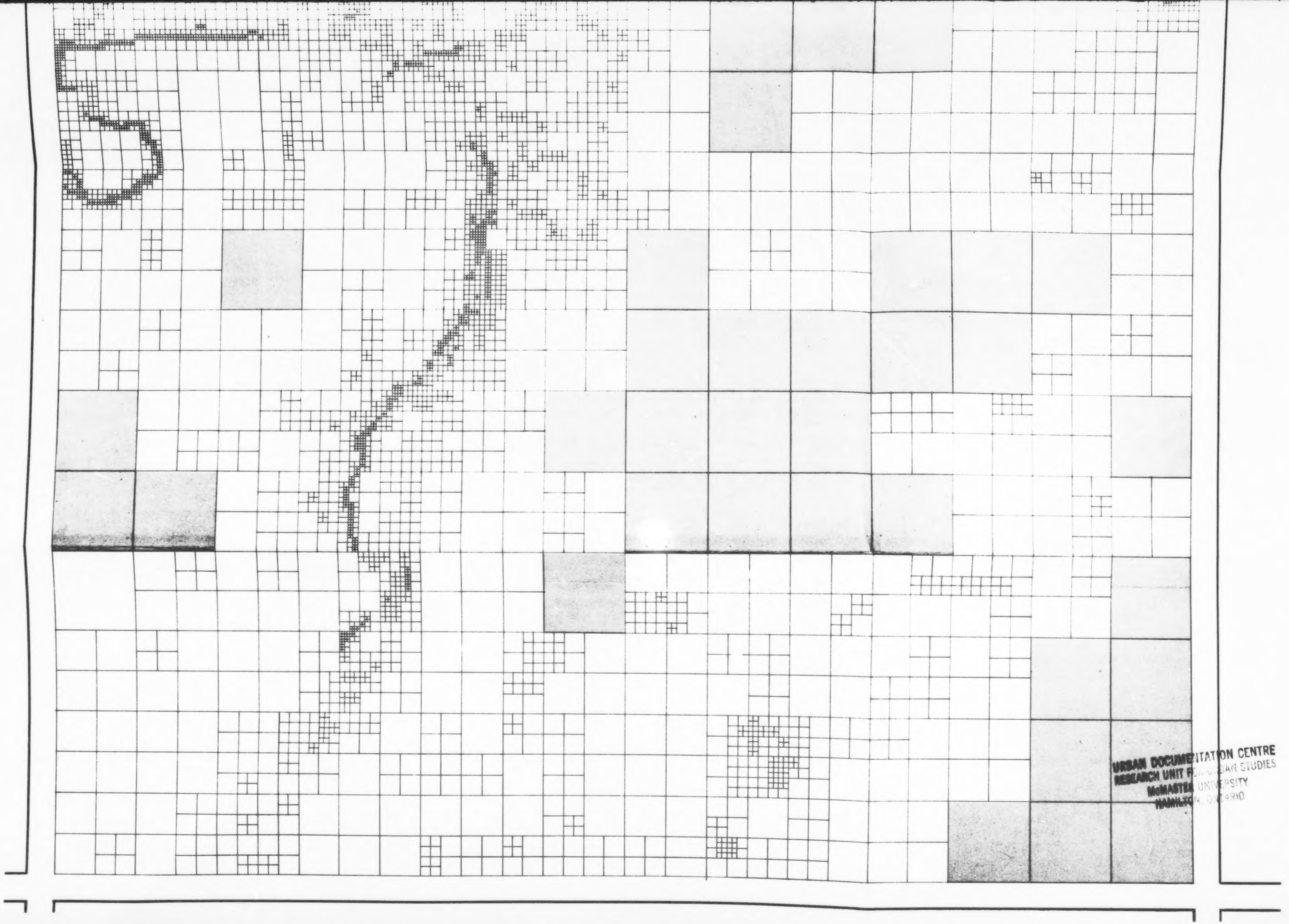
URBAN DOCUMENTATION CENTRE
RESEARCH UNIT FOR URBAN STUDIES
McMASTER UNIVERSITY
HAMILTON, ONTARIO



TOTAL AREA OF PLAN	
ACRES	HECT
206·5	83·7

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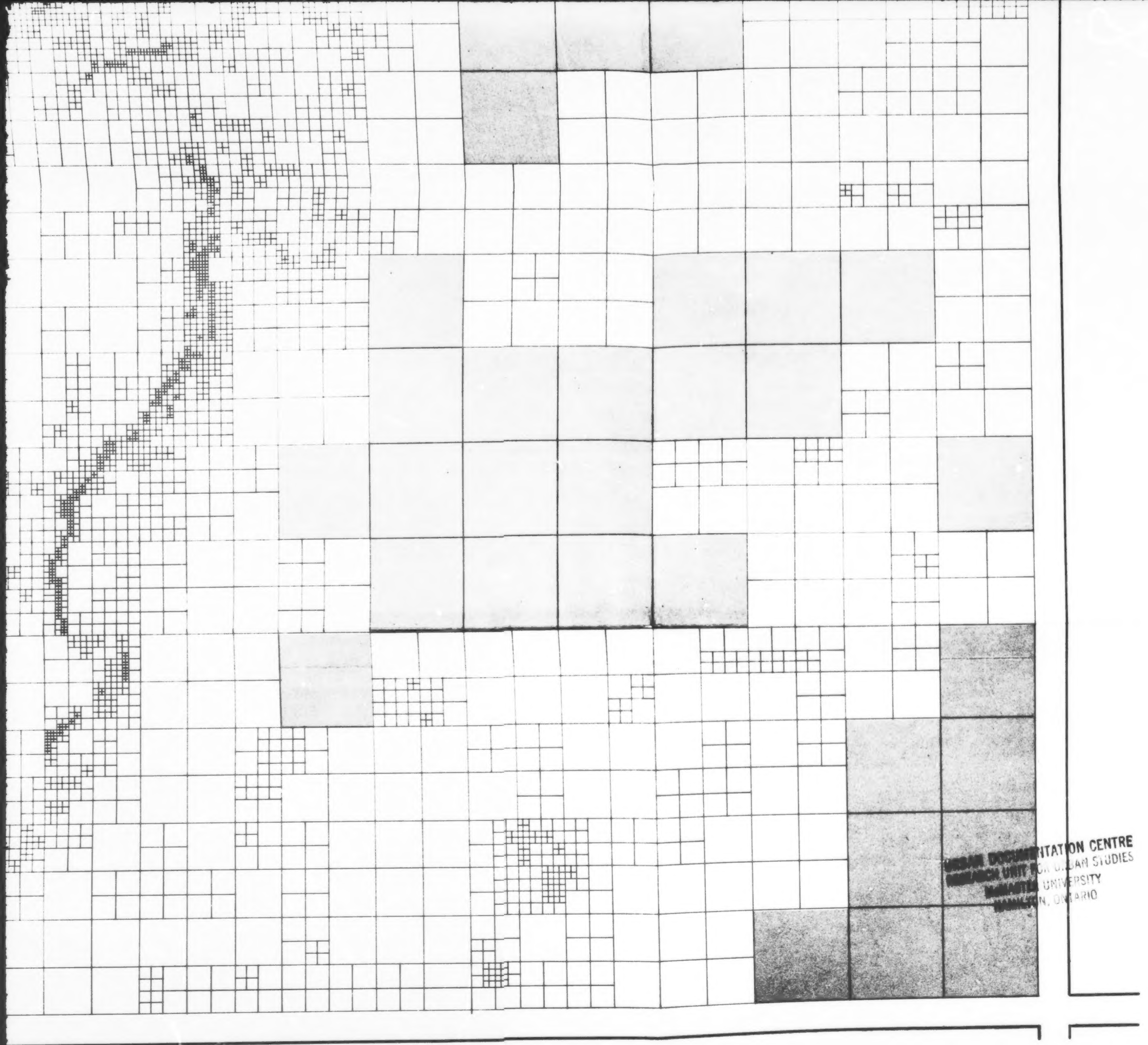
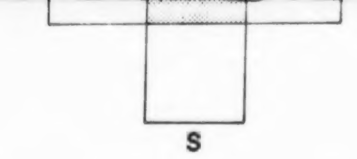
RESEARCH UNIT FOR URBAN STUDIES
McMASTER UNIVERSITY
HAMILTON, ONTARIO





TOTAL AREA OF PLAN		SHADED AREA		PERCENTAGE
ACRES	HECT.	ACRES	HECT.	
206·5	83·7	39·5	16	19·1

SLOPE DESCRIPTIVE MATRIX

DESIGN CRITERIA FOR ENERGY EFFICIENT NEIGHBOURHOOD PLANNING

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September 1982

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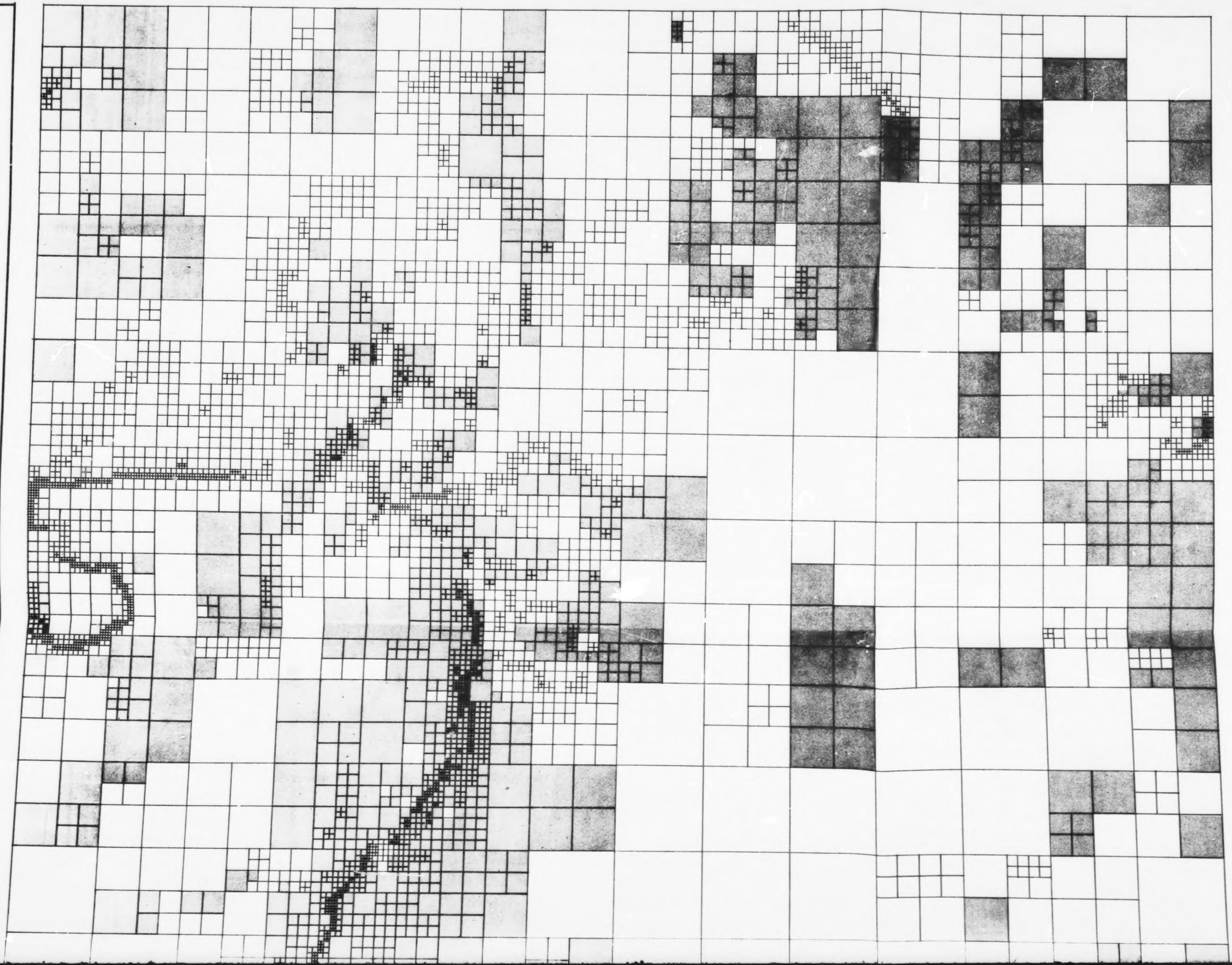
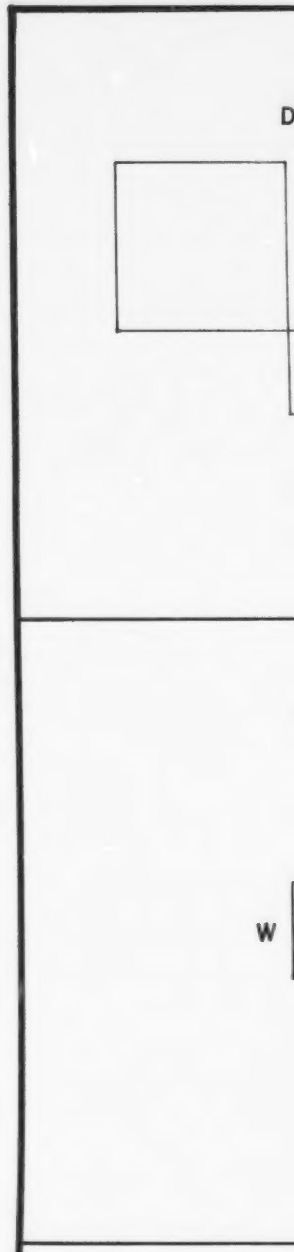
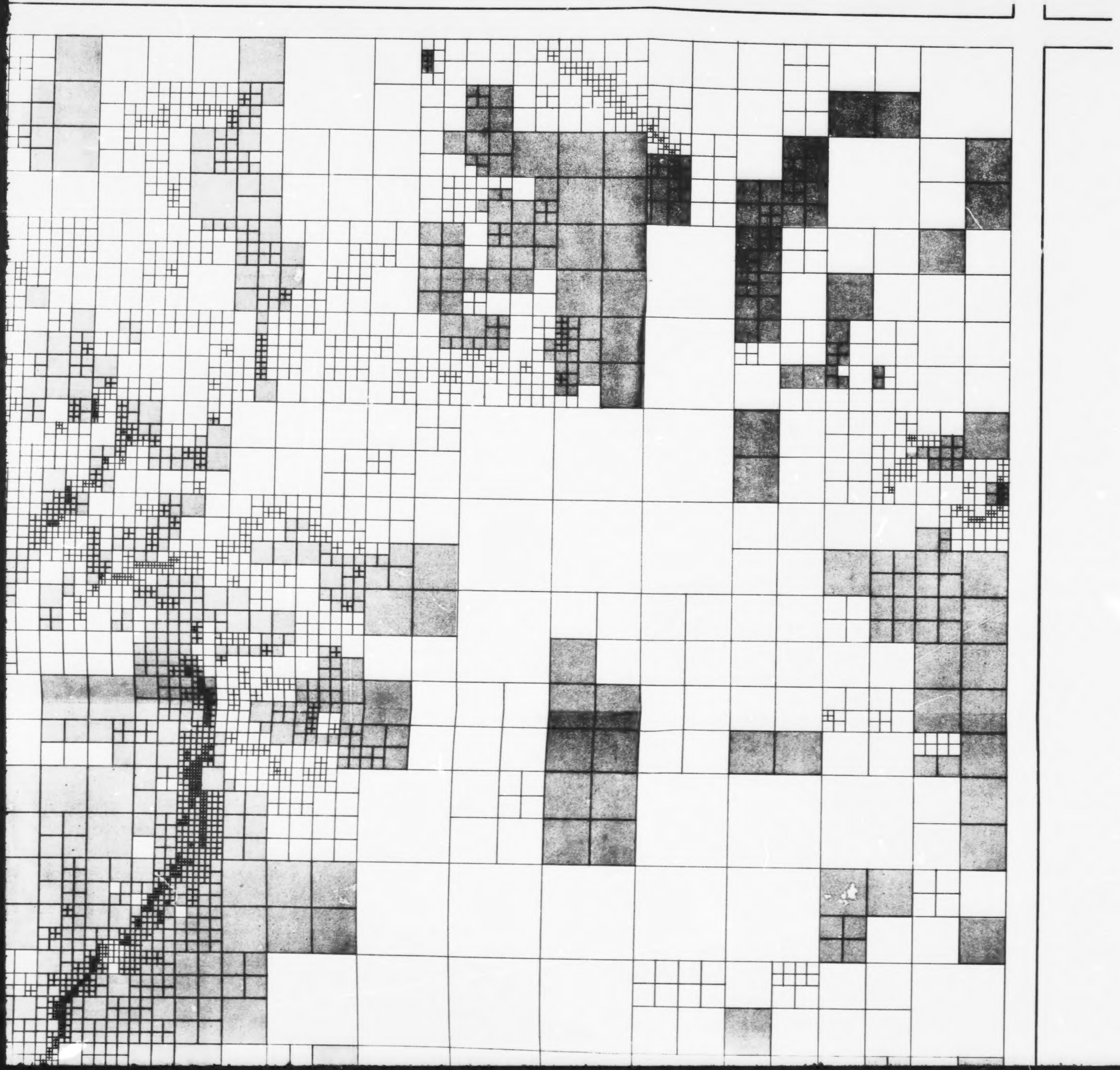
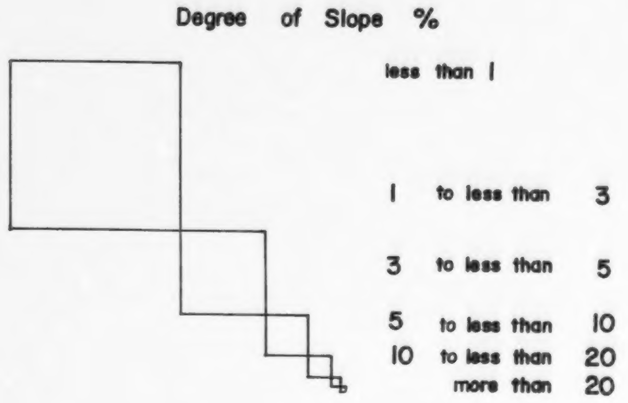
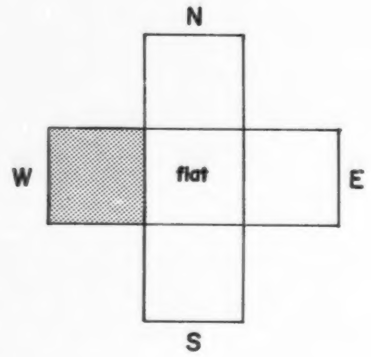




TOTAL AREA OF PLAN	
ACRES	HEC
206·5	83·




Degree of Slope %
less than 1
1 to less than 3
3 to less than 5
5 to less than 10
10 to less than 20
more than 20


Orientation of Slope
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TOTAL AREA OF PLAN		SHADED AREA		PERCENTAGE
ACRES	HECT.	ACRES	HECT.	
206·5	83·7	68·3	27·7	33·1

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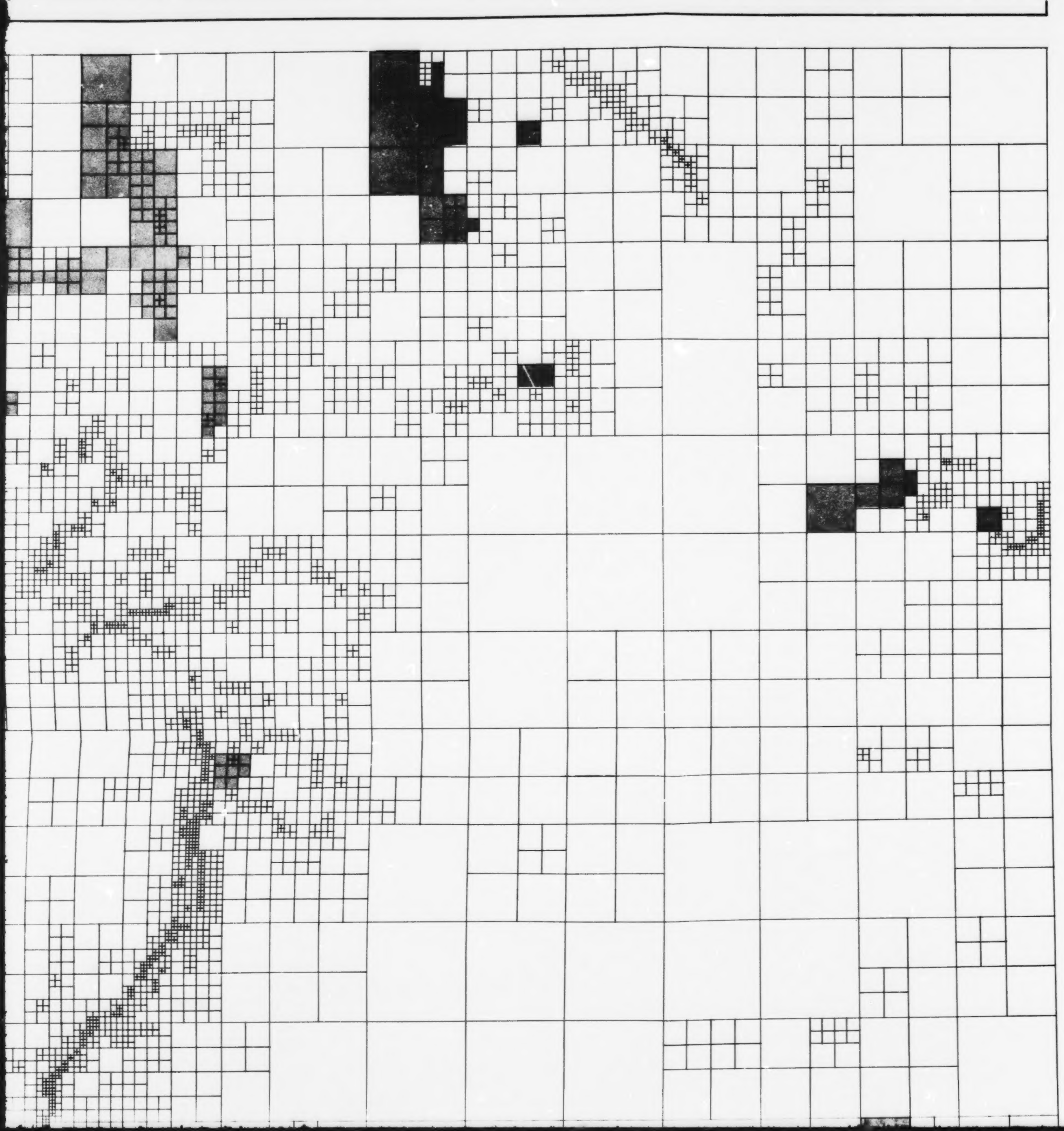
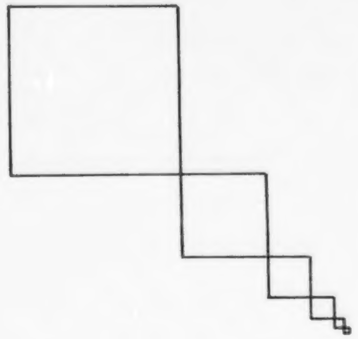
TOTAL AREA OF PLAN	
ACRES	HECT
206·5	83·7



Degree of Slope %



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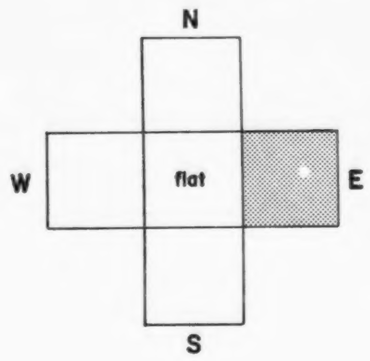
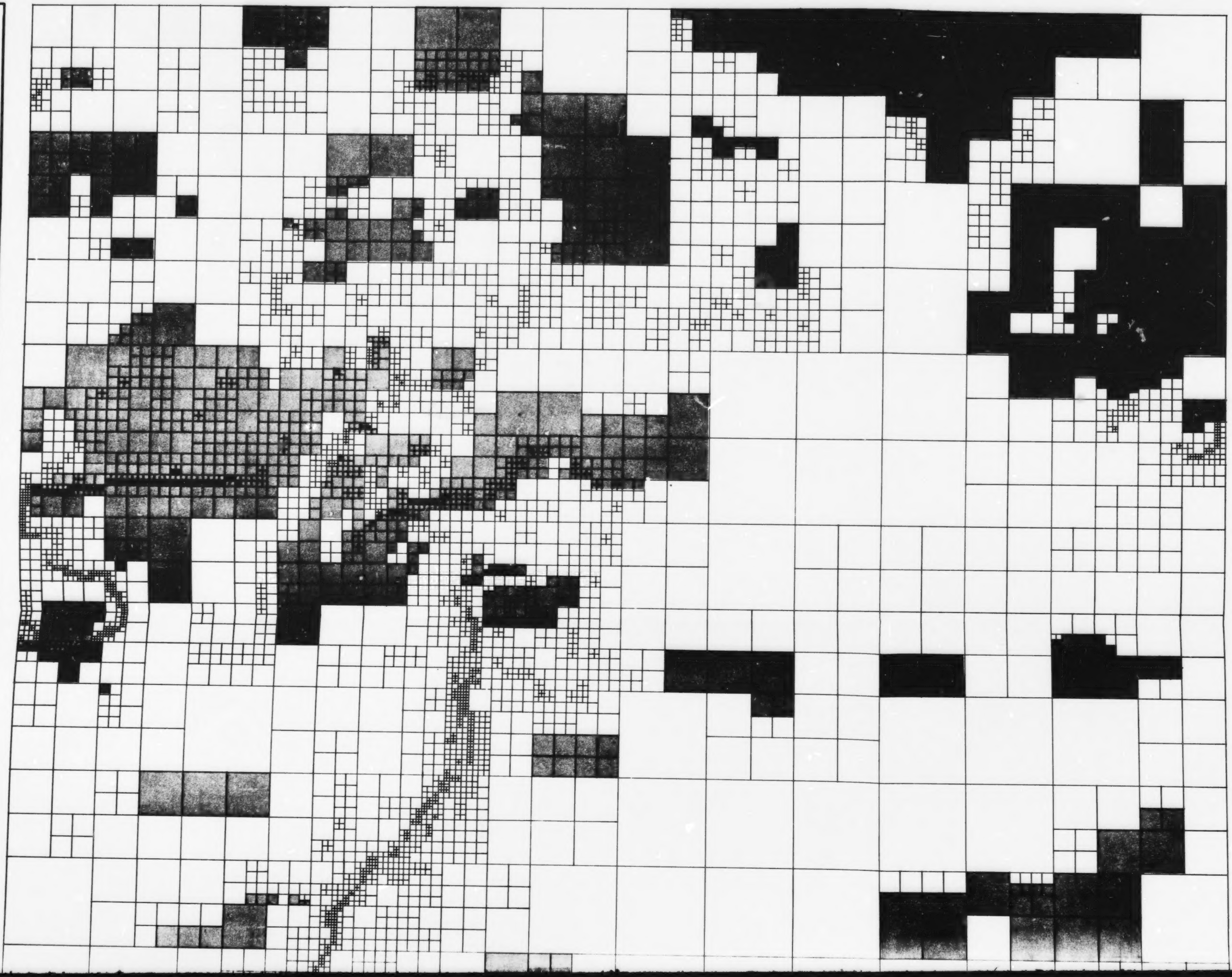
more than 20

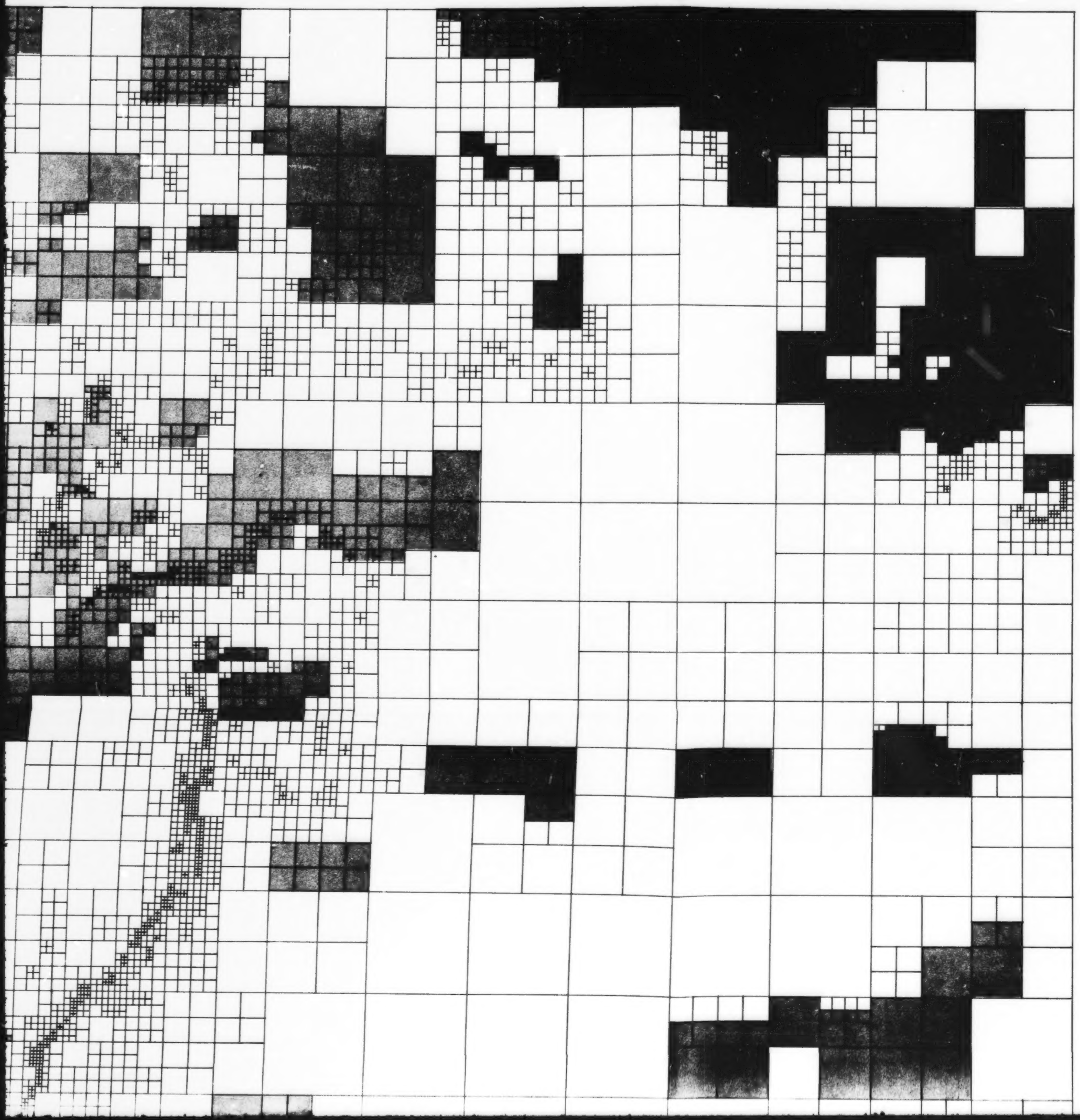
Orientation of Slope



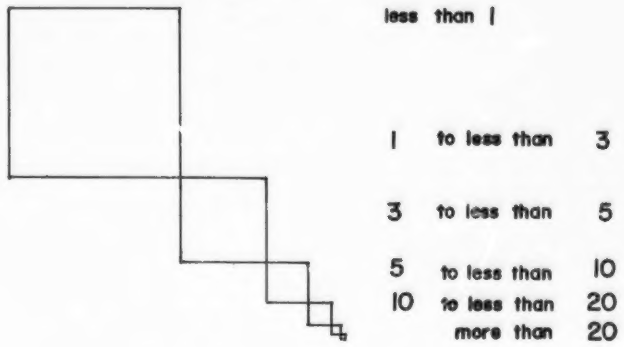
TOTAL AREA OF PLAN		SHADED AREA		PERCENTAGE
ACRES	HECT.	ACRES	HECT.	
206·5	83·7	13·2	5·4	6·4



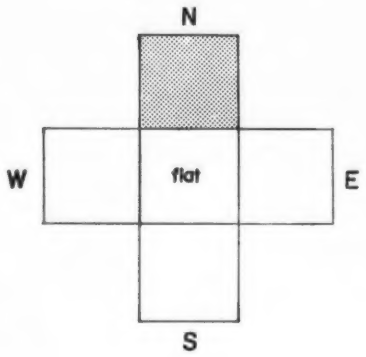
TOTAL AR OF PLA	
ACRES	HE
206·5	83



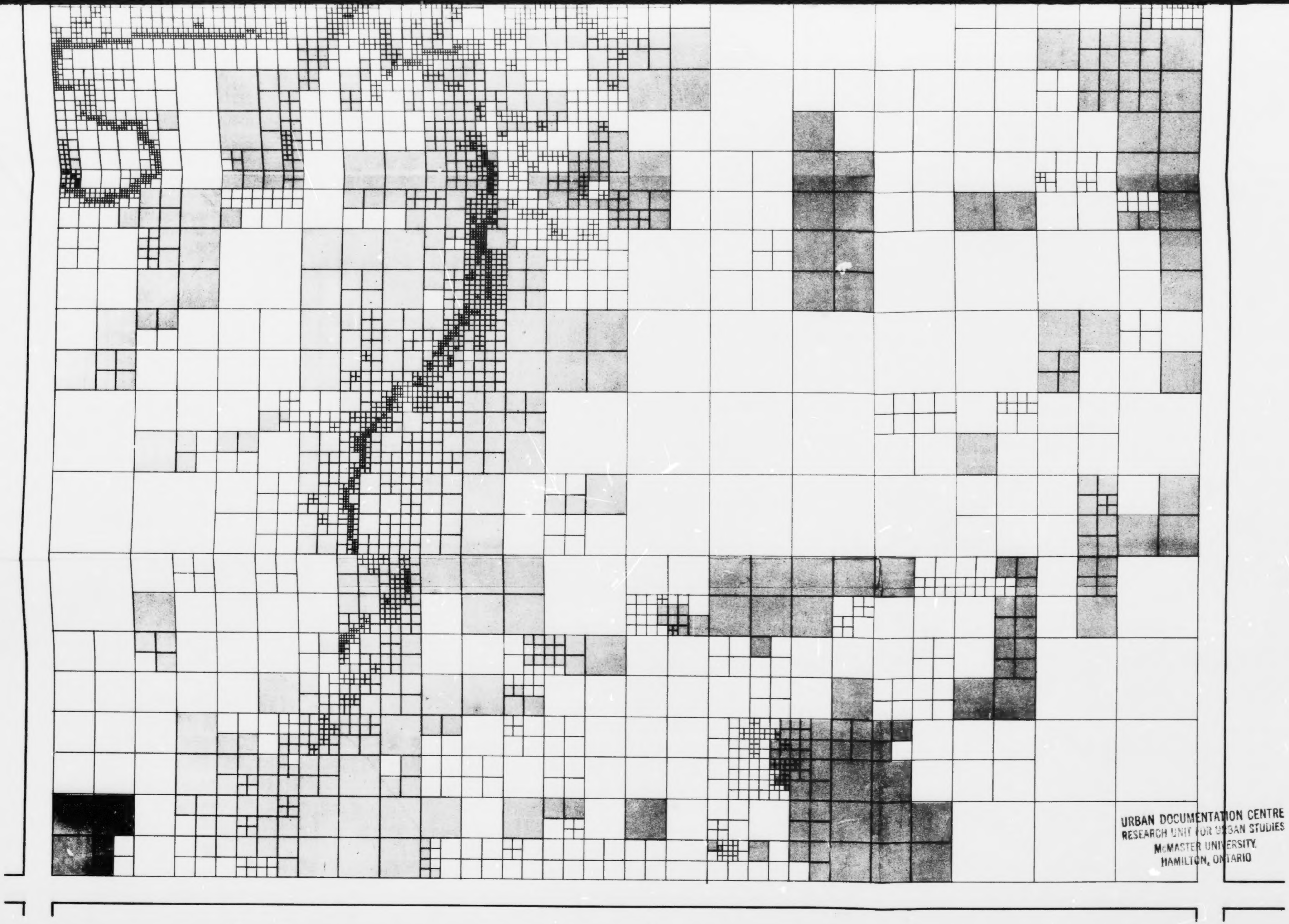
Degree of Slope %


less than 1
1 to less than 3
3 to less than 5
5 to less than 10
10 to less than 20
more than 20

Orientation of Slope



TOTAL AREA OF PLAN		SHADED AREA		PERCENTAGE
ACRES	HECT.	ACRES	HECT.	
206·5	83·7	44·1	17·9	21·4



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HAMILTON, ONTARIO

TOTAL AREA OF PLAN		SHA
ACRES	HECT.	ACR
206·5	83·7	68·

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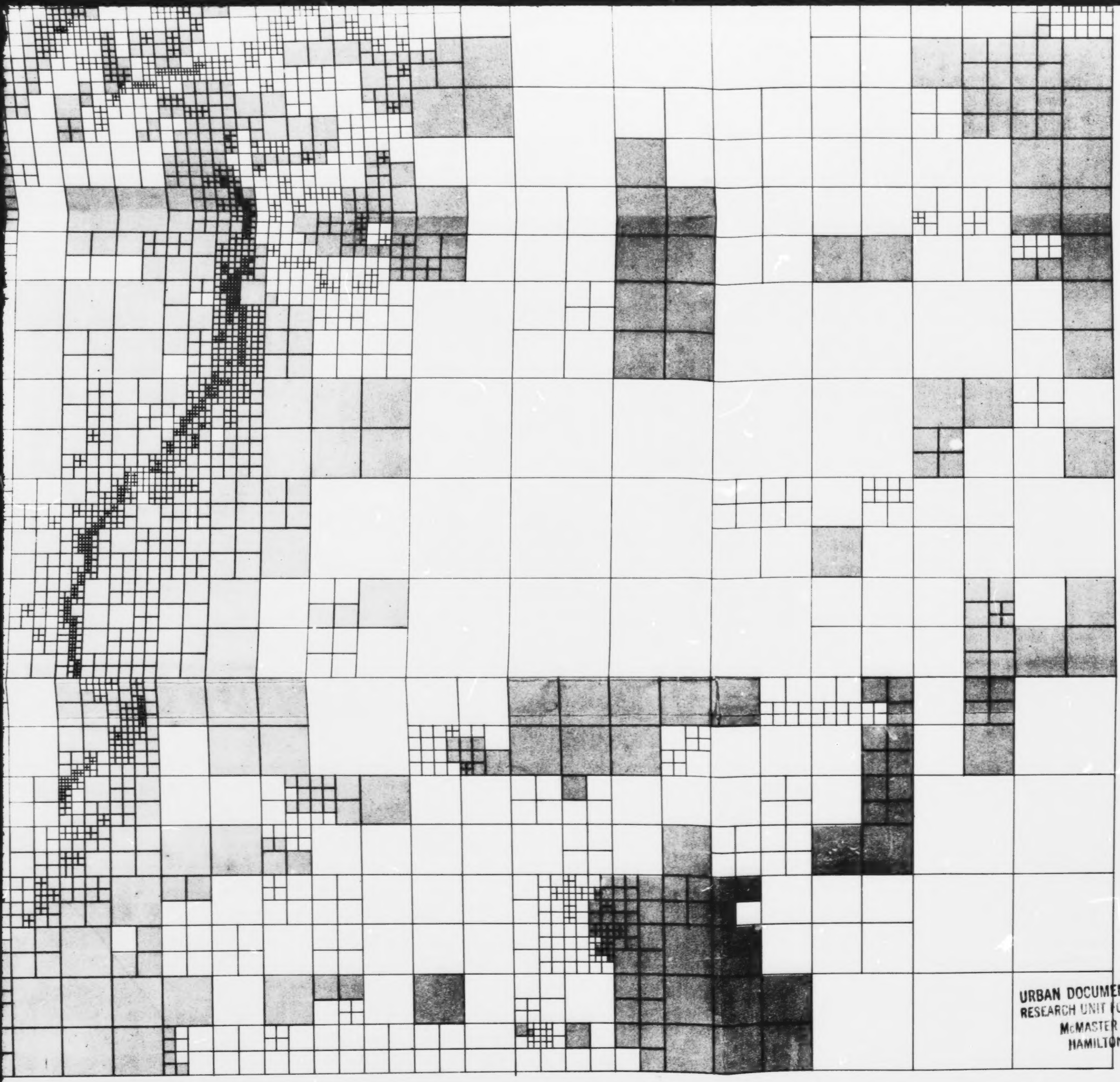

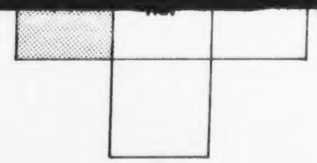

TOTAL AREA OF PLAN		SHADED AREA		PERCENTAGE
ACRES	HECT.	ACRES	HECT.	
206·5	83·7	68·3	27·7	33·1

SLOPE DESCRIPTIVE MATRIX

DESIGN CRITERIA FOR ENERGY EFFICIENT NEIGHBOURHOOD PLANNING

PREPARED FOR THE CITY OF HAMILTON
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OF THE
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September 1982

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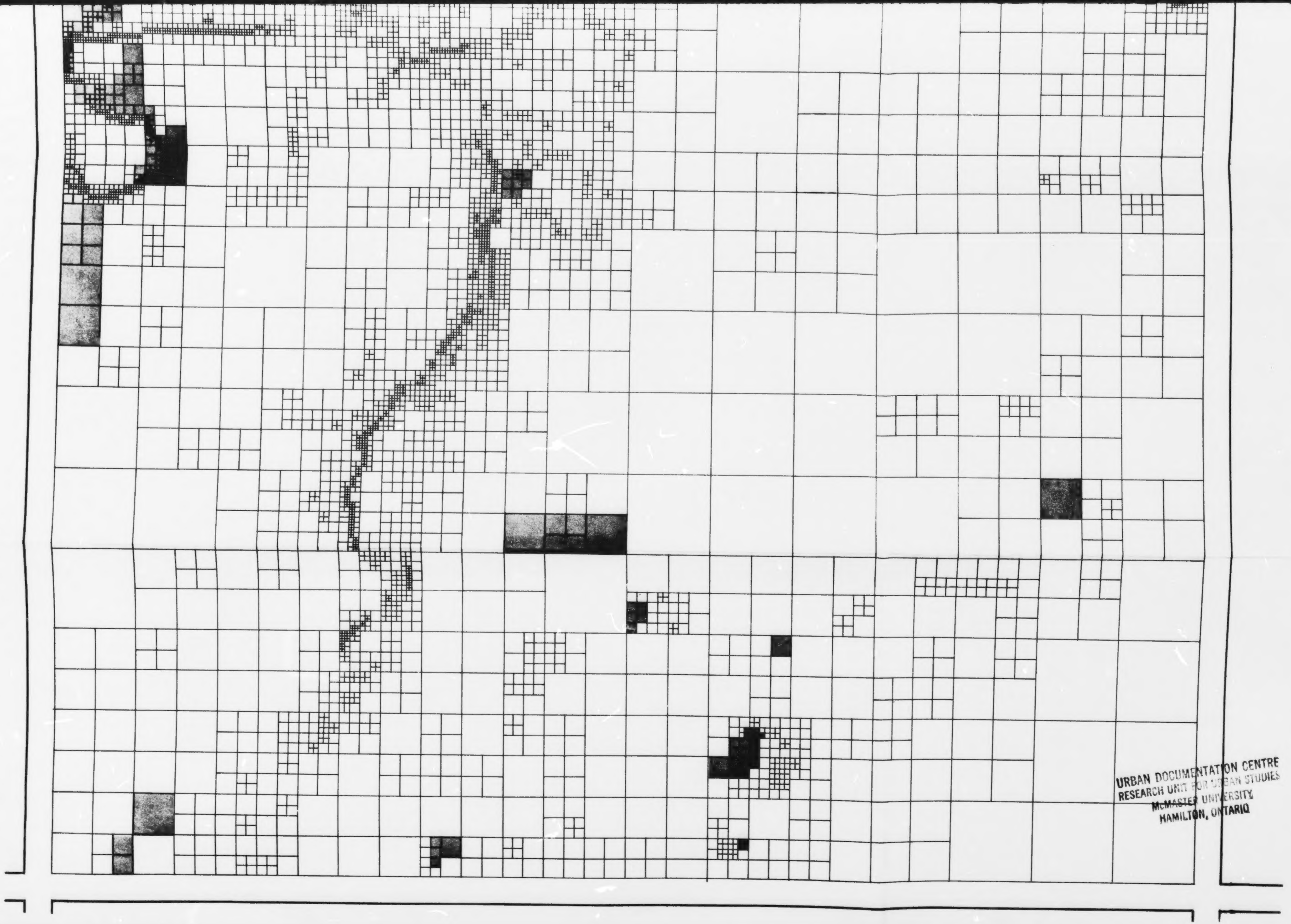
RESEARCH UNIT FOR URBAN STUDIES
McMASTER UNIVERSITY
HAMILTON, ONTARIO



URBAN DOCUMENTATION CENTRE
RESEARCH UNIT FOR URBAN STUDIES
McMASTER UNIVERSITY
HAMILTON, ONTARIO

TOTAL AREA OF PLAN	
ACRES	HEC
206·5	83·

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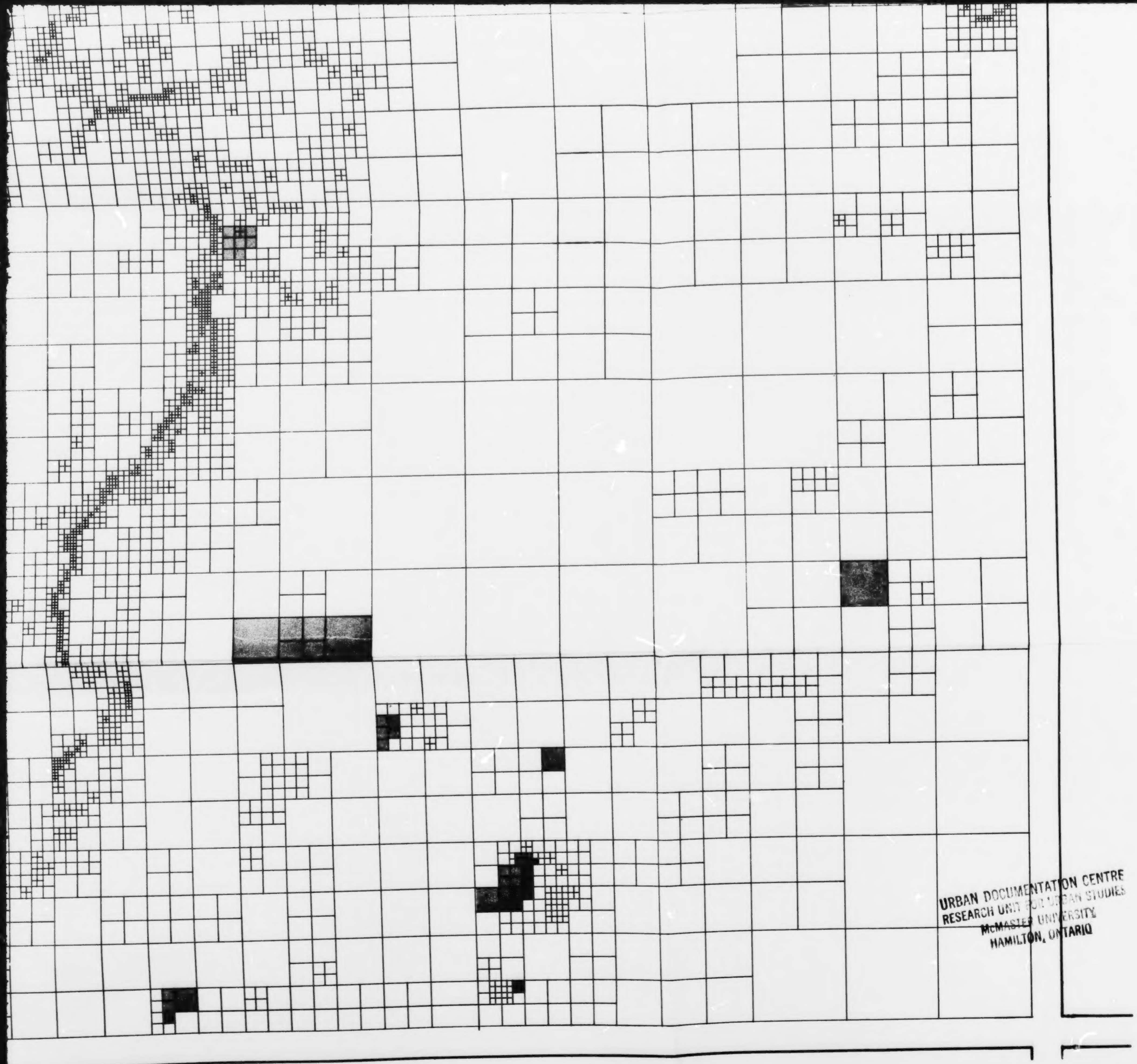

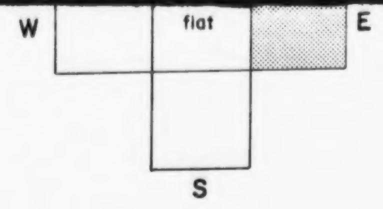

TOTAL AREA OF PLAN		SHADED AREA		PERCENTAGE
ACRES	HECT.	ACRES	HECT.	
206·5	83·7	13·2	5·4	6·4

SLOPE DESCRIPTIVE MATRIX

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September 1982

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HAMILTON, ONTARIO

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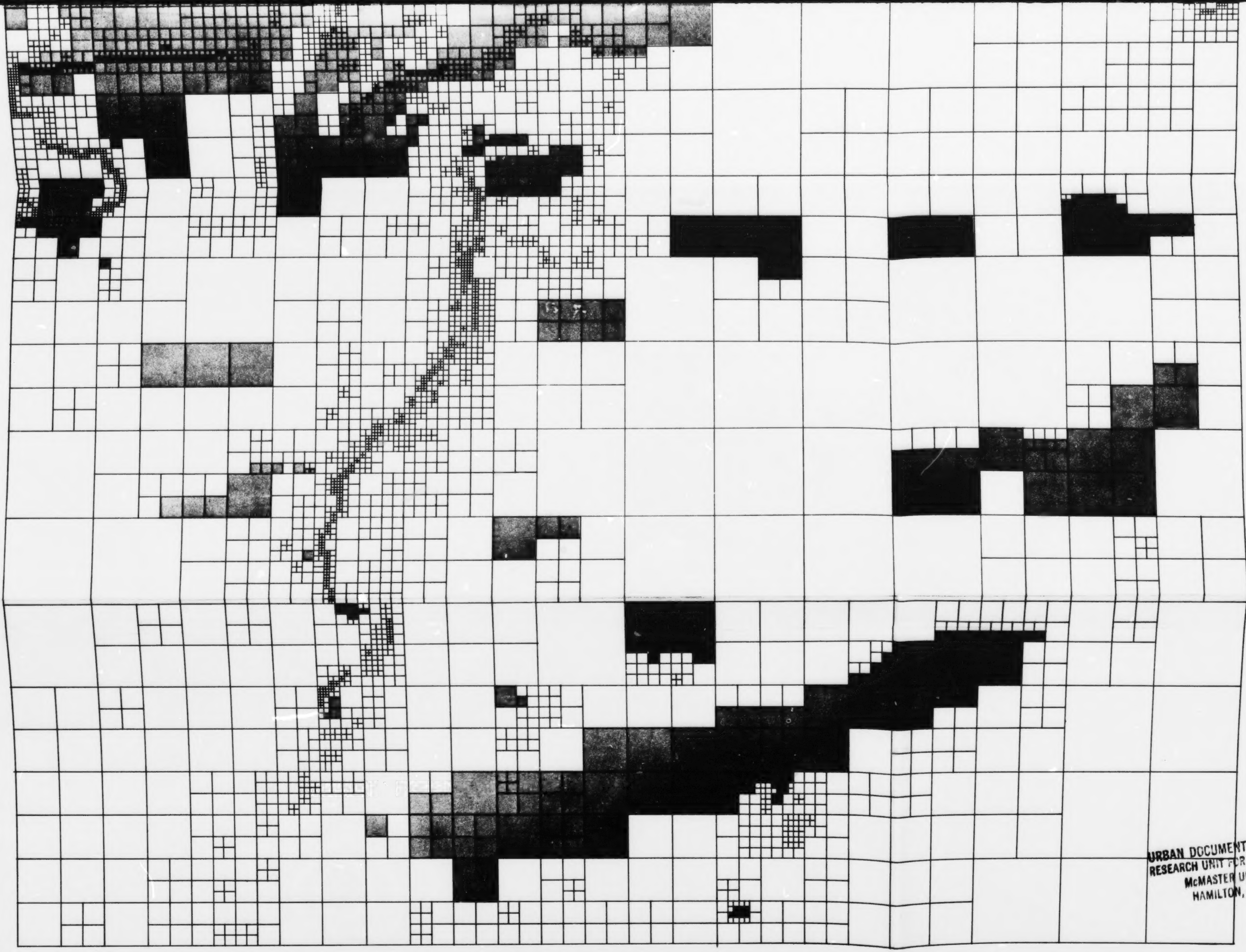

TOTAL AREA OF PLAN	
ACRES	HECT.
206·5	83·7

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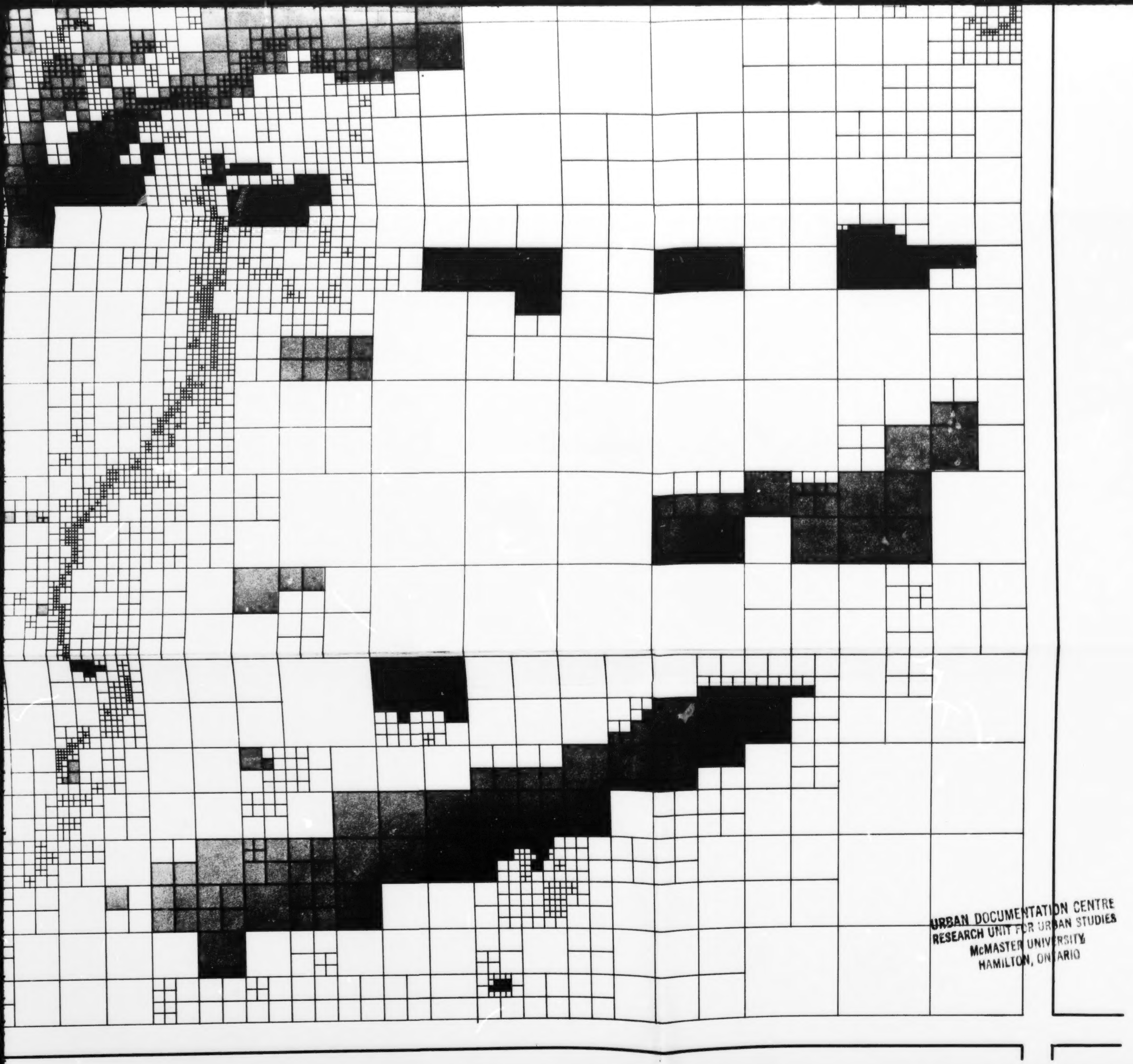
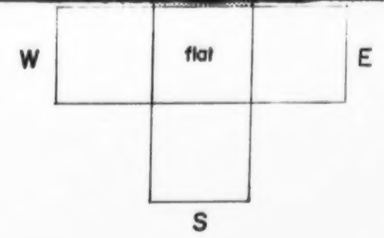
HAMILTON, ONTARIO





TOTAL AREA OF PLAN		SHADED AREA		PERCENTAGE
ACRES	HECT.	ACRES	HECT.	
206·5	83·7	44·1	17·9	21·4

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SLOPE DESCRIPTIVE MATRIX

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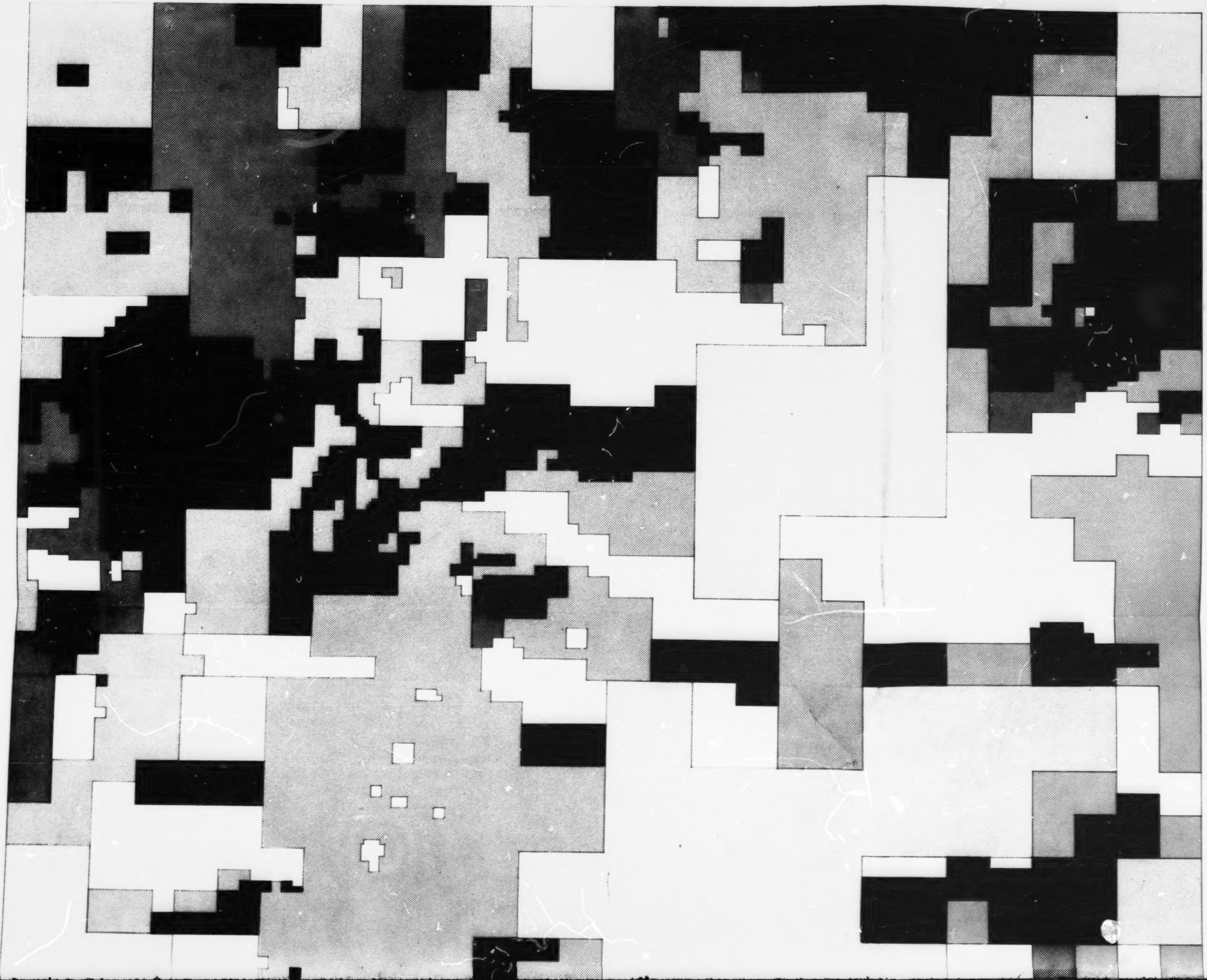
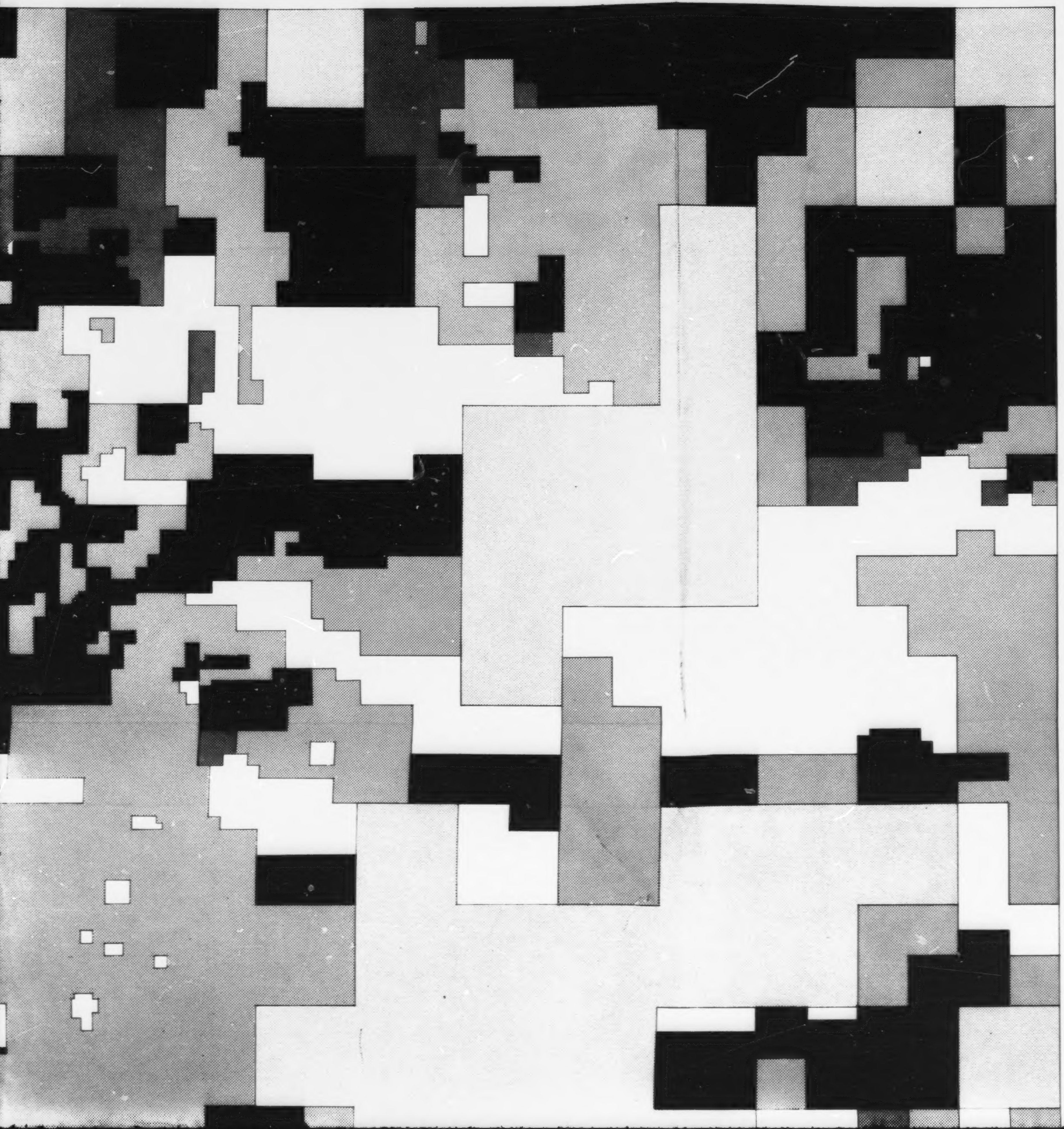
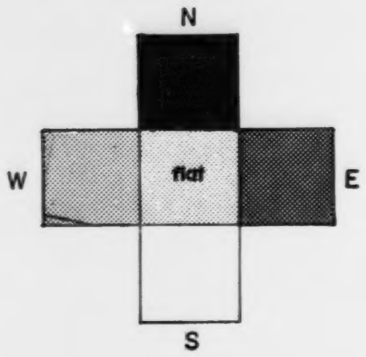


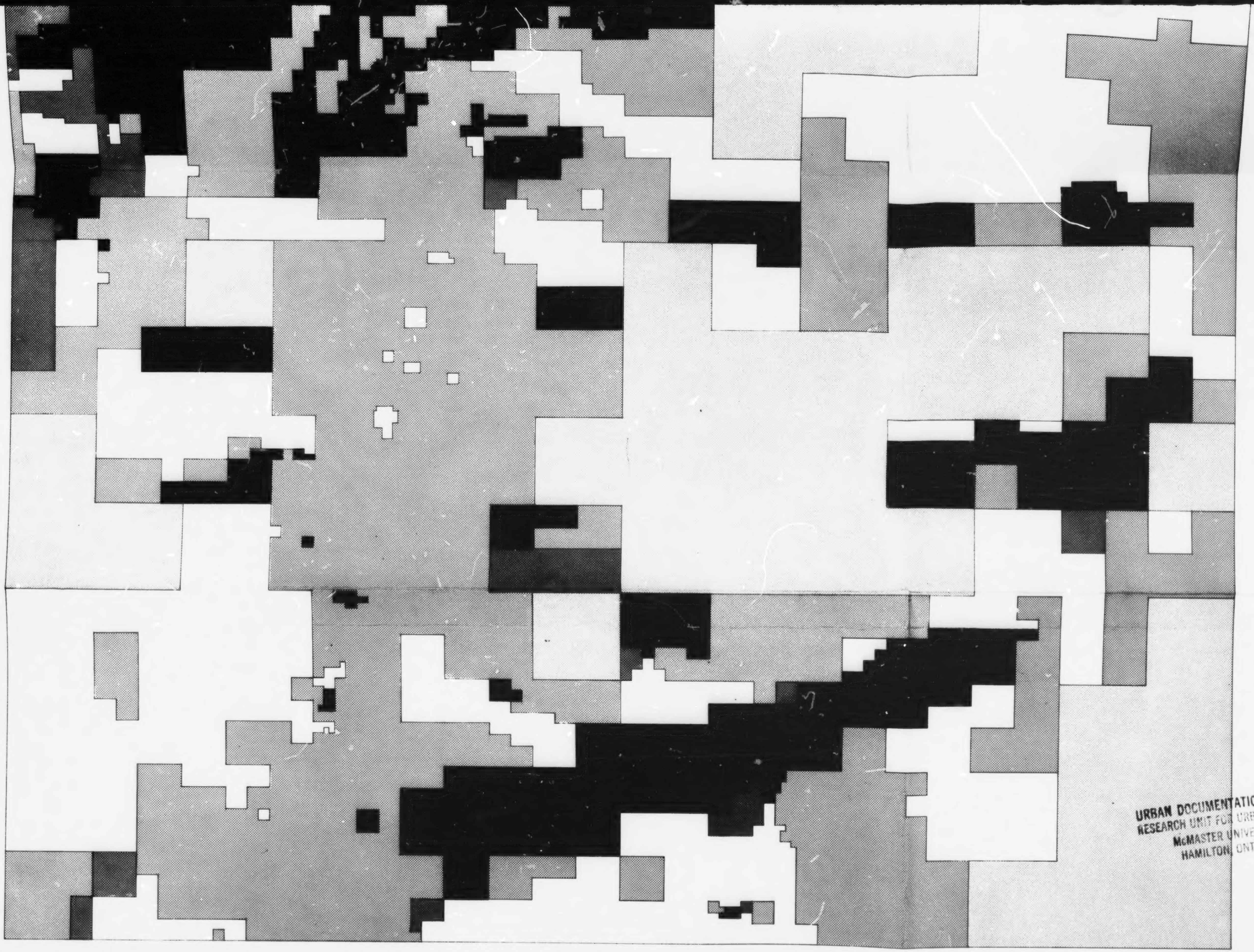
SLOPE	TOTAL AR OF PLA	
	ACRES	HE
S	206·5	83
F	206·5	83
W	206·5	83
E	206·5	83
N	206·5	[illegible]



Orientation of Slope



SLOPE	TOTAL AREA OF PLAN		SHADED AREA		PERCENT.
	ACRES	HECT.	ACRES	HECT.	
S	206·5	83·7	41·3	16·7	20
F	206·5	83·7	39·5	16	19·1
W	206·5	83·7	68·3	27·7	33·1
E	206·5	83·7	13·2	5·4	6·4



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HAMILTON, ONTARIO

SLOPE	TOTAL OF
	ACRES
S	206·5
F	206·5
W	206·5
E	206·5
N	206·5

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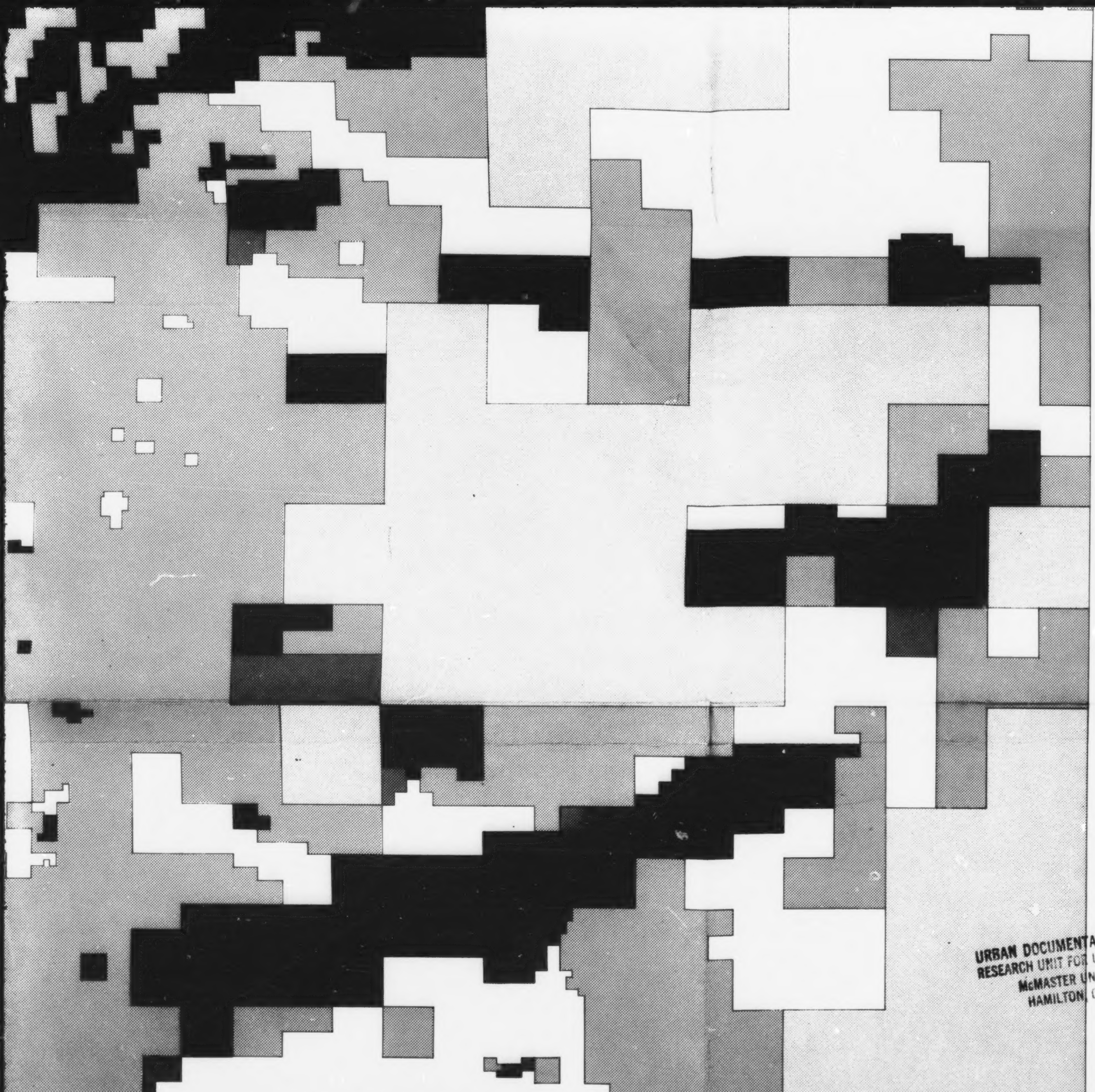
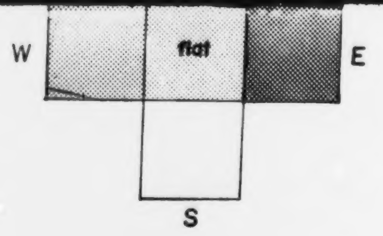


URBAN DOCUMENTATION CENTRE
RESEARCH UNIT FOR URBAN STUDIES
McMASTER UNIVERSITY,
HAMILTON, ONTARIO



SLOPE	TOTAL AREA OF PLAN		SHADED AREA		PERCENT.
	ACRES	HECT.	ACRES	HECT.	
S	206·5	83·7	41·3	16·7	20
F	206·5	83·7	39·5	16	19·1
W	206·5	83·7	68·3	27·7	33·1
E	206·5	83·7	13·2	5·4	6·4
N	206·5	83·7	44·1	17·9	21·4

SLOPE ORIENTATION DESCRIPTION

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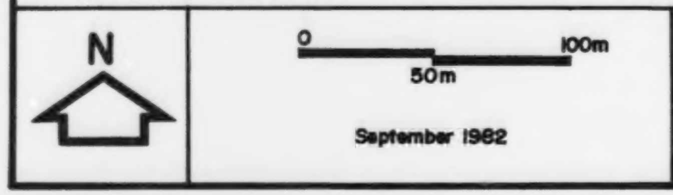

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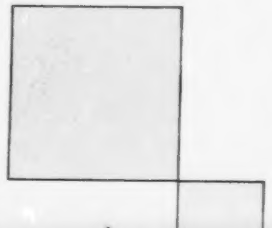
Degree of Slope %



less than 1

1 to less than 3

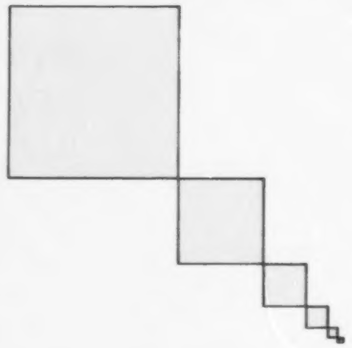
3 to less than 5

Orientation of Slope

Location of Study Area

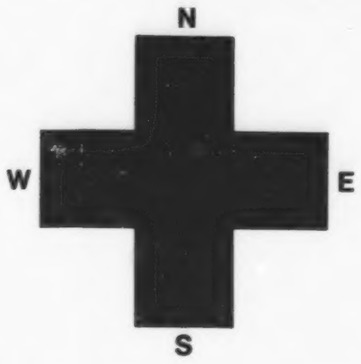
3 to less than 5

Degree of Slope %

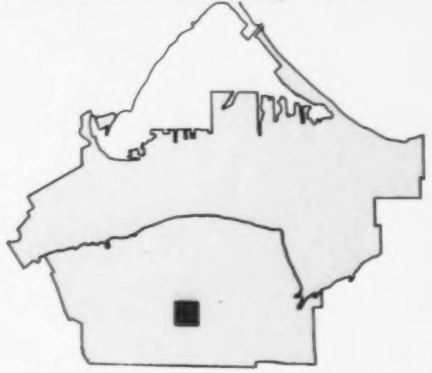


less than 1	
1 to less than	3
3 to less than	5
5 to less than	10
10 to less than	20
more than	20

Orientation of Slope



Location of Study Area



Slope Descriptive Synthesis

Design Criteria for Energy Efficient Neighbourhood Planning

Prepared for the City of Hamilton by the Planning and Development Department of the Regional Municipality of Hamilton-Wentworth

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